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ART. I.—*Contributions to Meteorology, being results derived from an examination of the observations of the United States Signal Service and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Thirteenth paper, with two plates.

[Read before the National Academy of Sciences, Washington, April 20, 1880.]

Great and sudden changes of temperature.

IN my third paper (this Journal, vol. x, p. 10,) I called attention to the great and sudden changes of temperature which frequently occur in some parts of the United States, and noticed a very remarkable case which occurred at Denver, Colorado, in January, 1875. As the observations for this month at all the stations of the Signal Service have now been published, I propose to examine this case more particularly, and also to present some additional facts connected with the same subject. My third paper contains two tables, showing for each station of the Signal Service for the years 1873 and 1874, the number of cases in which the difference between the maximum and minimum temperatures of the same day amounted to at least 40°. I have extended this comparison to the four years of observations since published in the Annual Reports, and find 118 stations at which at least one such case was reported. As the table is too large to be published entire, I have retained only those stations at which the average number of cases amounted to at least six annually. The following table exhibits these stations arranged in the order of frequency of great changes of temperature. Column first shows the names of the stations; column second their latitude; column third their longi-

tude from Greenwich; column fourth their elevation above the sea; columns fifth to sixteenth show the total number of cases observed in each of the months of the year; column seventeenth shows the aggregate number of cases for each station; column eighteenth shows the number of months of observations at each station; column nineteenth shows the average number of cases for one year; and column twentieth shows the annual rain fall at each station expressed in inches. An asterisk shows that observations for the month indicated are wanting.

Diurnal change of temperature at least 40°.

Station.	Lat.	Long.	Elev. feet.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Sum.	Months.	Year.	Rain, Inches.
	°	°																	
Wickenburg	34·0	112·7	2050	2	9			13	23	9	16	22	21	21	10	146	11	160	4·99
LaMesilla	32·3	106·8	4000	14	12	7	17	8	12	*			4	17	5	96	11	105	3·56
Campo	32·4	116·5	2486	1		3	2	7	12	7	28	18	*	*	*	78	9	104	18·53
Tucson	32·2	110·9	1898	*	5	13	6	9	8	*	*	*	*	*	*	41	5	98	13·03
Prescott	34·5	112·5	5580	8		4	3	7	20	*	*	6	8	13	12	81	10	97	13·81
Ft. Craig	33·7	107·1	4619			4	8	6	4		8	6	8	2	1	47	12	47	
Colorado Sp.	38·9	105·0	6032	22	11	11	6	12	19	8	1	3	7	8	9	117	30	47	15·84
Winnemucca	41·0	117·7	4335	2			2	2	1	6	14	7	7	1	1	43	12	43	5·66
Uvalde	29·2	99·7		4	4	4				6	6	2	3	6	3	38	11	41	23·31
Benton	47·9	110·5	2674	5	7	7		2				6	7	1	1	36	12	36	12·17
Denver	39·7	105·1	5269	20	7	17	13	10	24	16	9	29	18	10	11	184	69	32	13·81
Graham	33·0	98·5	900	*	4	8	2	1				*	*	*	*	15	6	30	18·28
North Platte	41·1	100·9	2838	10	7	10	9	1	4	2	1	6	21	11	5	87	42	25	28·77
Visalia	36·3	119·3	348							6	14	2				22	12	22	10·49
Fredericksb'g	30·3	98·7	1614	3	5	3				*	*	*	*	*	2	13	7	22	27·73
Stockton	30·8	102·8	4950	2	2	3	4		1	*				5	2	19	11	21	14·63
Concho	31·4	100·3	1750	4	4	7						1	1	1	2	20	12	20	23·83
Camp Verde	34·4	111·9	3160		1	3	2	*		3	7	2				18	11	20	10·81
Pilot Point	33·3	96·8			2	1	3	1		1	5		1	1	1	16	11	17	31·37
Cheyenne	41·2	104·7	6057	5	2	2	4	4	22	22	8	17	4	6	3	99	69	17	13·50
Dodge City	37·6	100·1	2486	4	10	12	4	3	2			1	11	10	4	61	45	16	24·87
Umatilla	45·9	119·3	461					3	4	2	6					15	11	16	8·36
Florence	33·0	111·3					1	2	2	*	*	*	*	5		10	8	15	7·18
Ft. Sully	44·6	100·7	1678	6	3	3	4	3	5	3	11	10	18	2	4	72	60	14	12·16
Ft. Griffin	32·9	99·3		2	4	2	3	1								12	12	12	37·96
Breckenridge	46·2	96·3	968	2	6	4	1	7	3	5	1	10	20	5	4	68	69	12	38·57
York Factory	57·0	92·4	55	1		1	1		2	10	1					16	17	11	14·54
Rockliffe	46·2	77·7	418	2		2	3	2	5	1	1					16	18	10	
Yankton	42·7	97·5	1275	11	6	1	3	2	1			3	9	6	4	46	57	10	28·63
Pembina	49·0	97·1	790	2	2	2	2	12	2		4	5	10	3	5	49	62	9	22·47
Bismark	46·8	100·6	1706	5	1				2	2	2	4	12	2	3	33	45	9	18·37
Ft. Garry	49·9	97·0	754	3	3	3	2	13	6	3	3	3	5	2	3	49	66	9	29·19
Geneva	42·9	77·1	567				1	4	5							10	15	8	27·46
Brackettville	29·3	100·4	1026	1	2	1				2			1			7	12	7	26·18
Chatham	47·0	65·5	56	4	12	7	2	5							1	31	57	7	45·67
Parry Sound	45·4	80·2	635	3	5	2	2	1						1	4	18	34	7	40·44

Of the thirty-six stations here enumerated about half are situated south of latitude 35°, and these are the stations where the great fluctuations of temperature occur most frequently,

while the fluctuations of pressure attending the progress of the storms of the middle latitudes are but little felt. Moreover it will be noticed that these great fluctuations of temperature occur more frequently in summer than in winter. Hence it may be inferred that the principal cause of these fluctuations is independent of the progress of storms. This will appear if we examine the cases at Wickenburg, which stands at the head of the list. The following are the cases in which the diurnal change of temperature at Wickenburg exceeded 60°:

			Max.	Min.	Diff.				Max.	Min.	Diff.
1877.	July	27,	106°	42°	64°	1877.	Aug.	1,	109°	37°	72°
		28,	110	40	70			2,	107	43	64
		29,	106	44	62			3,	108	44	64
		30,	106	43	63			13,	112	46	66
		31,	106	30	76			14,	113	50	63

Wickenburg is situated in a desert region where the annual rain-fall is only five inches; where, during the day, the sand becomes intensely heated by the sun's rays; and where, on account of the dryness of the atmosphere the loss of heat by radiation at night must be about as great as at any other point of the earth's surface. A similar condition of things exists at all the stations named in the table south of latitude 35°.

At the stations further north, the rain-fall is generally small, and the air is ordinarily very dry. This remark will apply to all those stations at which the annual number of cases of these large fluctuations exceeds twelve. At some of the remaining stations, the fluctuations of temperature resulting from the progress of great storms becomes appreciable, viz: at Breckenridge, York Factory, Rockliffe, Yankton, Pembina, Bismark, Fort Garry, Geneva, Chatham and Parry Sound. Six of these stations are situated in that region where, after the passage of a center of low pressure with its high temperature, the cold winds from the north rush down with a violence unknown in any other part of the continent. It appears then that the most remarkable cases in the table are examples of the ordinary diurnal change of temperature unaffected by the passage of storms; and that the remaining cases are to be ascribed to the influence of storms combined with the ordinary diurnal change of temperature.

In order to test this question more fully, I determined the mean diurnal fluctuation of temperature at all the stations of the Signal Service west of the meridian of 90° from Greenwich. The annual reports of the Signal Service show the maximum and minimum temperature for each day of the year for each of the stations of observation. I determined the average of the maxima for each month, and also the average of the minima, and called the difference the mean diurnal fluctuation for that month. When there were observations for several

years, I took the average of the numbers obtained for the corresponding months of the different years. The following table shows the results for the several stations arranged in the same order as in the preceding table:

Mean diurnal fluctuation of temperature.

Station.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Wickenburg	36·0	35·5	19·7	19·5	37·0	43·6		50·2	40·9	40·2	42·0	33·4
La Mesilla	37·1	35·6	37·1	36·0	36·0	36·8		28·3	24·8	32·2	40·6	30·7
Campo	26·1	20·0	25·1	23·4	32·1	35·9	41·2	47·7	46·0			
Tucson		38·1	35·2	36·2	37·3	36·6						
Prescott	35·3	29·2	31·6	31·7	33·4	39·3			32·9	36·5	38·6	37·4
Ft. Craig	25·8	25·8	30·8	34·2	34·7	30·4	28·4	33·4	33·8	29·9	31·4	24·0
Colorado Sp.	29·0	28·7	28·2	30·0	29·5	32·4	28·8	29·1	28·4	28·7	28·3	30·2
Winnemucca	25·7	18·8	22·6	25·6	28·4	29·9	35·6	37·8	33·9	30·7	24·4	29·5
Uvalde	28·4	29·8	28·7	26·1	18·2	22·8		34·7	30·7	28·6	31·7	22·6
Benton	29·5	30·8	24·0	25·4	23·9	24·3	28·7	25·7	32·1	29·0	23·7	24·0
Denver	25·8	25·0	27·8	27·5	27·3	30·3	29·8	29·8	30·2	28·6	26·9	26·2
Graham		28·0	33·7	30·3	23·6	19·9	22·7	24·7				
North Platte	25·4	24·8	25·0	25·4	22·1	25·1	27·5	24·9	27·2	28·4	24·9	25·5
Visalia	18·7	15·9	19·1	22·5	29·1	33·3	35·8	38·0	33·9	28·1	24·0	19·0
Fredericksb'g	31·7	33·1	31·2	27·8	25·2	24·1	25·7					
Stockton	28·2	32·6	29·3	31·6	28·0	28·1		27·4	24·4	26·0	29·0	21·2
Concho	26·5	28·5	32·0	26·5	22·1	21·4	24·2	25·4	23·4	24·5	25·4	20·4
Camp Verde	28·0	28·7	29·6	27·3		33·5			29·9	30·0	34·0	20·3
Pilot Point	24·1	28·6	32·5	30·2	31·0	26·1	30·6	35·1	29·4	24·1	26·3	25·1
Cheyenne	23·1	23·0	24·9	24·6	26·1	30·4	30·4	30·1	29·3	26·0	23·6	23·2
Dodge City	22·1	24·5	26·8	25·2	24·0	24·4	24·3	22·9	24·6	26·3	26·0	24·1
Umatilla	13·6	16·0	22·2	25·6	28·3	30·6	29·8	32·4	27·2	25·0	15·5	10·2
Florence	28·1	26·9	26·3	26·4	32·3	31·0					34·3	22·8
Ft. Sully	24·8	21·7	21·8	24·3	23·8	26·7	28·0	28·4	27·2	25·9	21·5	22·2
Ft. Griffin	23·4	28·0	31·4	29·1	25·9	21·8	25·8	25·2	25·3	19·6	23·1	19·8
Breckenridge	21·0	21·3	21·7	20·4	23·8	22·7	25·0	22·8	24·7	24·7	18·2	20·4
York Factory	17·0	19·1	22·3	21·2	19·7	23·3	24·8	21·7	16·2	12·4	15·7	15·9
Yankton	22·9	21·8	19·3	23·2	21·0	20·4	21·7	23·0	22·5	23·7	21·0	20·0
Pembina	20·9	21·1	23·0	22·7	25·3	23·1	24·9	25·1	23·7	23·0	18·7	21·5
Bismark	19·6	19·6	19·2	20·3	22·1	22·4	24·3	25·9	24·7	28·3	20·9	20·0
Ft. Garry	20·1	18·7	22·9	22·1	26·0	25·2	27·1	24·8	25·5	21·9	18·0	21·4
Bracketville	24·3	25·9	24·7	23·3	18·1	21·2	28·2	27·1	25·4	24·0	24·0	18·8

This table shows that the ordinary diurnal fluctuation of temperature at the more southern stations is enormously great, and in some places exceeds 40° for months in succession. There can be no doubt that this fluctuation is mainly due to the direct effect of the sun's rays during the day, combined with the effect of radiation at night.

In order to study the same phenomenon in a dry climate in a different part of the world, I took Barth's Travels in Central Africa, 1849–55. Dr. Barth started from Tripoli, crossed the Great Desert of Africa, going south to latitude 9½° N. and returned to Tripoli. During this journey many observations of the thermometer were made, but the record was very fragmen-

tary and seldom included both early morning and mid-day. The following are the only cases I have found in which two observations of the same day differed as much as 40°. The table shows the date of observation; the temperature observed; the difference between the two observations of the same day; the latitude in which the observation was made and the elevation above the sea as accurately as can be determined from the published maps of the expedition:

Temperature in Central Africa.

Date.	Temp.	Diff.	Latitude.	Alti'e feet.	Date.	Temp.	Diff.	Latitude.	Alti'e feet.
1850.	°	°	° ′		1852.	°	°	° ′	
April 13. 5.15 A. M.	50	41·8	30 37	531	Jan. 26. Sunrise.	52·7	40·5	11 36	900
2 P. M.	91·8				1.30 P. M.	93·2			
14. 5 A. M.	43·2	42·8	30 37	531	Mar. 23. Sunrise.	58	43·5	11 47	830
Noon.	86				2 P. M.	101·5			
24. 5.30 A. M.	40·1	42·3	28 20	696	April 1. Sunrise.	63	43·2	11 40	900
Noon.	82·4				1.30 P. M.	106·2			
25. 5 A. M.	46·4	63·0	27 46	921	Nov. 25. Sunrise.	41	50	12 55	880
2 P. M.	109·4				1.30 P. M.	91			
July 12. 5.15 A. M.	65·3	41·4	25 37	1435	Dec. 5. Sunrise.	47	47	13 0	900
1 P. M.	106·7				1.30 P. M.	94			
18. 4.45 A. M.	64·4	41·4	25 05	1349	1853.				
2.15 P. M.	105·8				April 12. Sunrise.	64	44	13 15	
Nov. 12. Sunrise.	43·7	42·3	18 23	1894	2 P. M.	108			
1.15 P. M.	86				April 13. Sunrise.	66	43	13 15	
1851.					2 P. M.	109			
Mar. 18. Sunrise.	64·4	44·6	12 47	1360	1855.				
1 P. M.	109				June 18. Sunrise.	69	40	19 42	1000
1852.					2 P. M.	109			
Jan. 7. Sunrise.	59	41·4	10 18	900					
1.30 P. M.	100·4								

These observations bear an obvious resemblance to those made in Arizona, and show that in a very dry climate the diurnal fluctuations of temperature are excessive, and seem to leave no doubt that this is the chief cause of the great changes of temperature shown in the table on page 2, and that at the more northern stations this cause is combined with the fluctuations which result from the passage of violent storms.

There is one important circumstance of which no account has thus far been taken, viz: the extreme suddenness of the changes of temperature which are sometimes experienced and of which an example occurred at Denver, January 15, 1875. What is the cause of these sudden changes? The first fact, which attracts our attention, is that the air at Denver and its vicinity is ordinarily very dry. This will appear from the following table showing for the year 1878 the mean relative humidity at all the stations of the Signal Service between the Sierra Nevadas and the meridian of 90° west longitude:

Stations.	Humid.	Stations.	Humid.	Stations.	Humid.
Pioche, Nev.	40·3	Dodge City, Kan.	62·3	Vicksburg, Miss.	69·0
Santa Fe, N. Mex.	42·4	St. Louis, Mo.	63·9	Shreveport, La.	69·3
Winnemucca, Nev.	42·4	Corsicana, Tex.	65·7	Davenport, Iowa	69·5
Denver, Col.	44·0	Bismark, Dak.	66·4	Omaha, Neb.	69·6
Salt Lake City, Ut.	45·1	Denison, Tex.	66·7	Yankton, Dak.	69·7
Cheyenne, Wyo.	50·8	Ft. Gibson, Ind. T.	67·5	Keokuk, Iowa	70·3
Boise City, Idaho	54·1	Dubuque, Iowa	67·9	Pembina, Dak.	72·1
Virginia City, Mont.	54·5	New Orleans, La.	68·5	Duluth, Minn.	73·0
Red Bluff, Cal.	54·7	Leavenworth, Kan.	68·7	Indianola, Tex.	73·3
Umatilla, Oregon	59·5	Memphis, Tenn.	68·8	Galveston, Tex.	74·7
North Platte, Neb.	61·6	St. Paul, Minn.	68·8	Breckenridge, Minn.	76·0
Pike's Peak, Col.	62·0	LaCrosse, Wisc.	68·9		

Plate I exhibits the curves of equal relative humidity for the stations east of the Rocky Mountains, showing that on the east side of these Mountains there is a narrow belt of territory where the mean relative humidity is less than one-half; and there is a belt at least 400 miles wide where the mean humidity is less than two-thirds; and in advancing eastward we find the humidity to increase still further. What is the cause of this dry atmosphere? Only one explanation seems possible. The westerly winds from the Pacific Ocean have their moisture mostly condensed in passing over the Sierra Nevadas, so that between these Mountains and the Rocky Mountains, the air is generally extremely dry. By passing over the Rocky Mountains there is a further condensation of vapor, so that when the air descends on the eastern side of these Mountains it is almost destitute of moisture. The vapor which comes up from the Gulf of Mexico is diffused over the Mississippi Valley, and mingles with the dry air which comes from beyond the Mountains, so that the dryness of the air rapidly diminishes as we advance eastward from the Rocky Mountains.

In order to determine whether the sudden changes of temperature, sometimes experienced near the level of the sea, ever result from the sudden descent of cold air from a great height, I have made an extensive comparison of the observations at Denver and Pike's Peak. The mean temperature at Pike's Peak is 30·8° below that at Denver, and the difference of elevation is 8882 feet, showing a fall of temperature of 1° for an elevation of 288 feet. This represents nearly the condition of equilibrium of a vertical column of the atmosphere. If the air at Pike's Peak should be 40° colder than at Denver it would tend to sink, and the air at Denver would tend to rise. I accordingly selected from the volumes of published observations (Nov. 1873 to Jan. 1875, and from Jan. 1877 to May 1877) all the cases in which the temperature at Pike's Peak was 40° lower than at Denver. The number of these cases in twenty months of observations was 343. Only thirty-nine of these

cases occurred during the seven winter months of observations, and they occurred most frequently in the month of May. As this table is too extensive to be published entire, I selected those cases in which the temperature at Pike's Peak was at least 45° lower than at Denver. These cases are exhibited in the following table, where column first shows the number of reference; column second shows the date of the observation. [The 7.35 A. M. observation is denoted by the figure 1 attached to the date; the 4.35 P. M. observation by the figure 2, and the 11 P. M. observation by the figure 3.] Column third shows the temperature on Pike's Peak; column fourth the relative humidity, and column fifth the direction and force of the winds on Pike's Peak; column sixth shows the temperature at Denver; column seventh the difference between the temperature at Denver and that at Pike's Peak; column eighth shows how much the pressure at Denver differed from the mean pressure for the month; column ninth shows the relative humidity; column tenth the direction and force of the winds; and column eleventh shows the direction of the upper clouds at Denver, with the amount of cloudiness (estimated in fourths of the visible heavens.)

The average humidity at Pike's Peak at the time of these observations was sixty-two, which was exactly the average humidity for the entire year 1878. The winds on Pike's Peak generally blew from a western quarter, and in only nineteen cases did they blow from any eastern quarter. The average velocity of these easterly winds was twelve miles per hour. The fluctuations of the barometer at Denver were generally small, being sometimes above and sometimes below the mean; but the average pressure was 0·10 inch below the mean. The easterly and westerly winds at Denver were almost exactly equal in frequency, but the velocity of the west winds was more than double that of the east winds. The upper clouds at Denver were almost invariably from the southwest or west, and were never from any easterly point, and the average cloudiness of the sky was more than one-half. The most noticeable circumstance exhibited by this table is the dryness of the air at Denver, the average relative humidity being only fifteen per-cent. There appears to be only one possible explanation of the source of this dry air, viz: that it came from the west side of the Rocky Mountains.

The facts thus stated appear to show that at the dates given in the preceding table there was seldom any extraordinary disturbance on Pike's Peak. In two cases (Nos. 60 and 61) hail was reported; in four cases (Nos. 23, 32, 43 and 59) sleet was reported, and in fifteen other cases there was either rain or snow. These facts seem to indicate an occasional uprising of

Temperature on Pike's Peak 45° lower than at Denver.

	Pike's Peak.					Denver.					
	1874.	Tem.	hum.	Winds.		Tem.	Diff.	Barom.	hum.	Winds.	Clouds.
1	Jan. 27.2	1°	43	N.W.	24	46°	45°	+·18	13	N.W. 18	0
2	March 2.2	11	61	S.W.	30	56	45	−·27	19	S. 15	4 W.
3	12.2	13	62	S.W.	20	58	45	+·11	12	S. 3	1 W.
4	15.2	5	100	S.	16	54	49	−·40	10	S. 15	4 W.
5	April 2.2	9	58	S.W.	16	55	46	+·14	22	E. 10	0
6	2.3	−6	62	S.W.	36	39	45	+·10	55	S. 5	0
7	9.2	12	80	N.	12	59	47	+·07	21	N. 4	0
8	10.2	21	58	S.W.	10	70	49	−·02	8	E. 5	1 S.W.
9	11.2	12	52	S.W.	28	64	52	−·21	7	S. 15	2
10	19.2	7	77	N.	12	53	46	−·19	42	S.W. 5	1 N.W.
11	24.2	12	81	N.	16	60	48	−·07	23	N.W. 18	2 N.
12	25.2	20	70	S.W.	32	68	48	−·01	21	S.E. 8	2 S.W.
13	26.2	23	47	N.W.	20	71	48	−·08	9	W. 11	3 S.W.
14	27.2	20	22	N.W.	16	66	46	+·23	19	S.E. 6	0
15	28.2	25	50	W.	20	73	48	+·16	13	E. 5	1 N.W.
16	29.2	28	30	N.W.	16	79	51	−·01	11	S. 6	2
17	30.2	27	32	W.	36	81	54	−·22	10	W. 5	2 W.
18	May 1.2	25	39	S.W.	20	73	48	−·50	16	N.E. 38	4
19	2.2	7	55	W.	36	56	49	−·25	15	N.W. 22	4 S.W.
20	8.2	25	39	S.	30	77	52	−·47	5	S.W. 32	4 S.
21	8.3	14	100	S.W.	36	59	45	−·32	27	S. 16	1
22	9.1	6	100	S.W.	20	51	45	−·42	45	S. 6	2 S.W.
23	9.2	11	90	N.W.	28	56	45	−·54	22	N. 12	4
24	10.2	18	69	W.	20	63	45	−·22	15	N.W. 24	3 S.W.
25	13.2	21	86	W.	20	70	49	−·04	12	N.W. 7	2 S.W.
26	14.2	18	84	N.W.	24	64	46	+·10	34	W. 3	3 S.W.
27	15.2	26	52	W.	16	72	46	+·17	14	S.E. 3	1 S.W.
28	16.2	30	78	N.	12	81	51	+·09	11	N.W. 7	2
29	17.2	31	38	S.W.	16	76	45	+·13	19	N. 22	4 S.W.
30	18.2	29	78	N.	8	87	58	+·07	14	E. 6	4
31	19.2	30	100	E.	4	82	52	+·05	12	S.W. 13	4 S.W.
32	20.2	27	100	S.	12	80	53	+·05	18	S. 16	4 S.W.
33	21.2	35	55	N.W.	12	80	45	·00	18	N.W. 11	4 S.W.
34	22.2	38	37	S.W.	12	85	47	−·03	15	N.E. 6	4 W.
35	23.2	37	45	S.E.	6	83	46	−·09	11	S. 16	4 S.W.
36	24.2	30	78	S.	4	81	51	+·08	22	E. 6	1 S.W.
37	25.2	36	61	S.	16	89	53	−·04	13	S.E. 12	1 S.W.
38	26.2	32	89	W.	20	78	46	−·18	19	W. 20	4
39	27.2	37	52	S.W.	24	87	50	−·35	10	S. 16	3 S.
40	27.3	27	100	S.	48	75	48	−·36	15	S. 20	4
41	28.2	31	39	S.W.	44	83	52	−·35	5	S.W. 15	2 S.W.
42	June 1.2	26	77	S.W.	77	71	45	−·09	28	S. 4	2 W.
43	3.2	32	79	S.W.	36	81	49	−·15	20	S. 8	4 S.W.
44	5.2	36	61	S.W.	30	83	47	−·09	21	N.E. 4	4 S.W.
45	6.2	36	62	S.W.	40	81	45	−·10	29	S.E. 12	4 S.W.
46	12.2	33	52	S.W.	36	85	52	−·14	15	E. 4	4 S.W.
47	17.2	41	33	S.W.	18	90	49	−·11	7	N.E. 12	3 W.
48	19.2	45	19	W.	20	90	45	+·06	24	E. 23	4 S.W.
49	20.2	48	23	S.E.	6	93	45	+·13	13	S.E. 12	3 W.
50	22.2	50	11	S.E.	14	98	48	−·10	8	S.E. 20	2
51	July 1.2	38	46	S.	20	86	48	−·02	12	W. 14	4 S.W.
52	2.2	48	10	S.E.	10	95	47	−·04	10	S.E. 9	0
53	3.2	49	11	N.E.	8	97	48	−·07	4	N.W. 8	0
54	4.2	54	4	S.	16	100	46	−·15	0	E. 9	2
55	8.2	49	29	N.E.	22	96	47	−·05	7	N.E. 8	4 N.W.
56	12.2	50	22	N.E.	8	95	45	−·14	9	N.E. 6	1 S.W.
57	15.2	40	91	N.E.	14	85	45	+·11	27	N.E. 4	3

	Pike's Peak.					Denver.						
	1874.	Tem.	hum.	Winds.		Tem.	Diff.	Barom.	hum.	Winds.		Clouds.
58	July 16.2	42°	83	S.E.	6	91°	49	−·07	12	N.	12	3 N.W.
59	17.2	42	83	S.E.	10	90	48	−·14	22	S.E.	16	4
60	Aug. 6.2	40	82	S.W.	16	85	45	+·01	26	E.	4	4 S.W.
61	8.2	43	83	S.E.	12	92	49	−·04	11	E.	8	4 W.
62	15.2	47	29	N.E.	8	93	46	+·01	14	W.	4	4 S.W.
63	16.2	45	52	W.	8	90	45	+·02	12	N.E.	4	4
64	23.2	38	55	N.E.	8	86	48	+·02	17	N.	2	3 S.W.
65	Sep. 18.3	16	83	W.	32	76	60	−·01	39	E.	1	3 S.W.
66	23.2	23	100	N.E.	24	70	47	+·02	33	N.E.	7	3 W.
67	24.2	28	48	N.E.	22	74	46	−·10	28	Calm.		0
68	25.2	31	69	N.	14	80	49	−·19	3	N.W.	8	1 W.
69	28.2	35	52	N.E.	6	81	46	+·02	10	N.E.	2	0
70	30.2	35	31	N.	2	82	47	−·01	11	E.	4	3 W.
71	Oct. 2.2	34	79	S.W.	32	81	47	−·25	21	S.W.	5	4 S.W.
72	9.2	29	46	N.	16	76	47	+·06	54	N.E.	11	0
73	24.2	19	69	S.W.	52	65	46	−·42	16	N.E.	9	0
74	28.1	2	100	W.	60	47	45	−·39	23	N.W.	8	2 N.W.
75	Nov. 1.2	19	29	W.	22	64	45	+·06	0	N.W.	18	0
76	4.2	12	61	N.W.	44	57	45	−·28	14	W.	26	2 N.W.
77	5.2	20	70	S.W.	44	67	47	−·07	15	S.	10	0
78	6.2	20	70	S.W.	60	70	50	−·29	9	S.	17	4 S.W.
79	7.3	5	50	W.	56	51	46	−·08	23	N.E.	1	1
80	13.2	21	81	S.W.	60	66	45	−·25	10	N.E.	11	2 S.W.
81	20.2	9	57	W.	40	54	45	−·18	17	N.W.	18	0
82	22.2	1	100	W.	52	46	45	−·33	24	W.	24	1 S.W.
83	25.2	23	60	W.	44	69	46	−·16	21	W.	19	1 N.W.
84	Dec. 12.2 1877.	15	13	N.W.	19	60	45	−·16	18	N.	15	3 W.
85	Feb. 7.2	−5	100	N.E.	30	40	45	+·02	40	N.	20	0
86	Mar. 11.2	15	85	W.	42	61	46	−·12	5	N.W.	15	0
87	11.3	8	66	W.	39	54	46	+·05	39	E.	2	0
88	13.2	18	61	N.W.	28	64	46	+·09	8	N.W.	15	0
89	15.2	25	40	W.	32	73	48	−·11	–	W.	20	2 W.
90	18.2	22	27	N.W.	31	70	48	+·01	3	N.W.	22	2 W.
91	20.2	25	47	N.W.	26	70	45	+·04	4	N.W.	28	2 N.W.
92	31.1	−3	100	W.	24	42	45	−·45	13	W.	4	4
93	April 3.2	12	61	N.W.	18	57	45	−·08	15	N.W.	15	2 S.W.
94	4.2	20	55	S.W.	10	65	45	−·04	6	N.W.	10	0
95	5.2	20	70	S.E.	10	66	46	−·04	7	W.	4	2 W.
96	13.2	19	84	S.W.	23	64	45	−·09	20	S.E.	10	2 W.
97	15.2	22	72	W.	24	68	46	−·14	7	N.E.	5	2
98	20.2	21	70	S.W.	41	70	49	−·44	6	S.E.	28	0
99	21.1	5	100	S.W.	78	50	45	−·31	14	S.W.	10	0
100	21.2	17	83	S.W.	30	68	51	−·33	—	S.W.	20	2
101	30.2	16	66	N.W.	10	63	47	·00	19	S.W.	5	2 S.W.
102	May 4.2	16	83	N.W.	20	65	49	−·21	10	W.	16	3 W.
103	8.2	23	60	W.	25	76	53	−·09	7	S.	5	4 S.W.
104	9.2	23	60	W.	18	75	52	−·08	6	S.	5	2
105	14.2	21	50	S.W.	43	74	53	−·07	0	W.	20	2 S.W.
106	15.2	29	67	S.	15	74	45	+·09	5	E.	4	3 W.
107	17.2	21	85	S.W.	28	72	51	−·20	6	S.E.	4	4
108	19.2	17	100	S.W.	28	65	48	−·13	14	E.	3	2
109	26.2	32	64	W.	2	79	47	+·11	11	S.	8	2 S.W.
110	27.2	33	74	W.	17	83	50	+·06	0	N.E.	4	2 S.W.
111	28.2	30	63	S.W.	35	82	52	−·07	7	S.E.	12	3 S.W.
112	29.2	27	55	S.W.	42	81	54	−·35	3	S.	4	2
113	29.3	19°	85	S.W.	54	66	47	−·36	14	S.W.	12	2
114	31.2	14	83	W.	28	60	46	−·23	19	W.	20	4

the warm air, but it is remarkable that so few such cases occurred, and it will be noticed that a difference of temperature of at least 45° between Pike's Peak and Denver often continued from day to day for a long period. In May, 1874, it continued for sixteen successive days, and in April, 1874, it continued for nine successive days. Hence it may be inferred that during these periods there was no general uprising of the warm air, and descent of cold air. I think we may hence infer that dry air even when greatly heated, has but little ascensional

Temperature on Pike's Peak higher than at Denver.

	Pike's Peak.						Denver.					
	1873.	Tem.	hum.	Winds.		Clouds.	Tem.	Diff.	Barom.	hum.	Winds.	Clouds.
1	Nov. 28.1	6°	76	W.	40	4	0°	6°	−·09	71	Calm.	0
2	Dec. 20.1	4	50	W.	20	4 N.W.	2	2	+·06	74	Calm.	1
3	28.1	41	25	W.	6	0	27	14	−·07	63	S. 3	0
	1874.											
4	Jan. 4.3	1	12	N.	18	0	− 4	5	+·20	47	S. 6	0
5	5.1	10	20	N.	30	0	8	2	+·07	66	S. 6	0
6	Feb. 26.3	22	39	W.	32	0	13	9	+·16	62	S. 4	0
7	Dec. 14.1	15	48	N.	18	2	14	1	+·17	63	S. 5	0
8	17.3	0	70	N.	40	0	− 5	5	+·25	26	S. 5	0
9	19.1	6	52	N.	6	0	5	1	−·03	50	S. 4	0
10	29.1	5	75	W.	15	0	4	1	+·05	74	N.E. 6	0
	1875.											
11	Jan. 8.1	−2	100	S.W.	22	Fog.	−10	8	+·12	77	N.E. 12	4
12	8.2	0	100	W.	42	Fog.	−14	14	+·28	100	N.E. 5	4
13	9.1	−18	100	S.W.	38	2	−23	5	+·29	100	Calm.	0
14	12.1	−5	100	S.W.	1	4	− 8	3	−·11	100	N. 5	4
15	12.2	−2	100	S.W.	24	4	− 9	7	−·04	100	N.E. 8	4
16	12.3	−12	100	W.	32	4	−15	3	+·04	100	E. 4	2
17	13.1	−11	100	S.W.	36	4	−22	11	+·02	100	S.E. 4	1
18	13.2	−2	100	S.W.	24	Fog.	−11	9	+·06	00	N.E. 6	4
19	13.3	−3	100	S.W.	38	Fog.	−10	7	+·08	54	N.E. 5	3 N.
20	14.1	1	100	S.W.	36	0	−14	15	+·15	100	S.E. 2	0
21	14.2	8	100	S.W.	28	Fog.	− 4	12	−·06	64	N.E. 4	1 W.
22	14.3	5	100	S.W.	45	Fog.	1	4	−·21	71	N.E. 3	3 W.
23	15.2	12	100	S.	40	Fog.	10	2	−·07	17	N.E. 8	4
24	16.2	15	100	S.W.	40	Fog.	10	5	+·14	58	N. 3	2 W.
25	16.3	11	100	S.W.	55	Fog.	7	4	+·08	77	Calm.	2
26	17.1	10	100	S.	20	Fog.	1	9	−·02	71	N. 6	2
27	17.2	16	100	S.	42	Fog.	4	12	−·03	74	N. 8	4
28	18.1	11	100	S.W.	20	Fog.	1	10	+·12	71	N. 1	0
29	18.2	15	100	W.	35	Fog.	14	1	+·03	63	N. 2	4 W.
30	18.3	13	100	W.	20	Fog.	12	1	+·05	61	S. 3	3 W.
31	19.1	10	100	W.	30	1	9	1	·00	57	S. 6	0
	1877.											
32	Jan. 11.3	7	100	S.W.	15	4	2	5	+·05	100	N.E. 5	4
33	12.1	2	100	N.W.	8	Fog.	− 6	8	+·07	81	Calm.	0
34	12.3	8	100	S.W.	8	Fog.	7	1	+·10	77	S. 5	0
35	13.1	7	100	S.W.	8	Fog.	1	6	−·02	72	S. 1	0
36	15.3	−5	100	S.W.	32	4	−10	5	−·16	77	S. 2	0
37	18.1	0	70	S.W.	46	2 S.W.	0	0	+·05	85	Calm.	0
38	22.3	11	75	W.	19	1	− 5	16	+·19	82	S. 5	0
39	24.1	7	54	S.W.	26	3	0	7	+·30	*85	S. 4	0

force, and that the violent uprising of heated air, which is frequently witnessed in humid climates, especially during thunder storms, is mainly due to the presence of a large amount of aqueous vapor.

I next made a comparison of the cases in which the temperature at Denver was lower than at Pike's Peak. These cases are thirty-nine in number, embraced in a period of twenty months' observations, and they are shown in the preceding table which is arranged like that on pages 8 and 9.

It will be noticed that thirty-one of these cases occurred in the month of January, and all occurred in the four months from November to February. The average relative humidity on Pike's Peak at these dates was eighty-four, and at Denver seventy-one. On Pike's Peak about half of the winds were from the southwest, and none of them were from any eastern point. The average velocity of the winds was twenty-seven miles per hour. At Denver the wind never blew from any western point, and its average velocity was only four miles per hour. At Pike's Peak the average cloudiness (counting fog as sky entirely overcast) was 0·71; and at Denver 0·36. The barometer at Denver was sometimes below the mean and sometimes above it, but the average was ·06 inch above the mean. One of the most noticeable circumstances exhibited by this table is the humidity of the air at Denver, showing that this air did not come from the west side of the Rocky Mountains, and the same fact is indicated by the observed direction of the winds.

We thus learn that during periods of severe cold at Denver, the thermometer is frequently lower there than it is on Pike's Peak, and hence we must conclude that this cold did not result from the subsidence of air from the upper regions of the atmosphere.

In order to test this conclusion more fully, I selected all those cases in which the thermometer at Denver sunk as low as +5° from November, 1873, to June, 1878, and the lowest temperature at Pike's Peak for the same date was entered in the same table. The number of these cases was ninety-nine. The average of these observations at Denver was −2·4°, and the average at Pike's Peak was −9·0°, showing that it was only 6·6° colder at Pike's Peak than at Denver.

I next made a similar comparison for Mt. Washington and two neighboring stations. I selected all the cases from November, 1873, to June, 1878, in which the thermometer at Burlington, Vt., sunk as low as +5° and determined the lowest temperature on Mt. Washington for the same dates. The number of these cases was 145. The average of these observations at Burlington was −2·7°, and at Mt. Washington −18·9°, showing

a difference of 16·2°. The average difference of temperature of these stations, as determined from six years' observations, is 19·0°. I next selected all the cases in which the thermometer at Portland, Me., during a period of five years sunk as low as +10°, and determined the lowest temperature on Mt. Washington for the same dates. The number of these cases was 111. The average of these observations at Portland was +3·2°, and at Mt. Washington was −19·7°, showing a difference of 22·9°. The average difference of temperature of these stations for a period of six years has been 19·7°. If we take the average of the results for Burlington and Portland, we shall find that during these cold periods the difference of temperature between Mt. Washington and the level of the sea was identically the same as shown by the daily observations of six years.

These results do not sustain the theory which I formerly advocated, that periods of severe cold are mainly the result of cold air descending from the upper regions of the atmosphere. The high temperature, shown on Pike's Peak at the time of the observations on page 10, appears also in the average temperature at that station for the winter months, and may reasonably be ascribed to the heat developed during the winter months by the condensation of vapor on the Sierra Nevadas and the western slope of the Rocky Mountains.

The way is now prepared for a consideration of the sudden changes of temperature which frequently occur at Denver and other places in its vicinity. These changes occur most frequently in the months of November, December and January; and the month of January, 1875, was specially noticeable for the magnitude and suddenness of these changes. The following are the principal cases which occurred in the last-mentioned month. January 3d the thermometer fell 28° between 3 and 5 P. M.; January 5th the thermometer fell 8° in less than thirty minutes; January 8th the thermometer fell 54° in six hours from 1 to 7 A. M.; January 14th the thermometer rose 39° in thirty-five minutes; January 15th the thermometer fell 48° in one hour. In my third paper (this Journ., x, p. 12) I stated the principal facts relating to the last two changes. In order to study this subject more fully I have selected from the volumes of published observations, the temperature at Denver, and the neighboring stations for the dates of the three regular observations (7:35 A. M., 4:35 P. M. and 11 P. M.) during the period including the changes above mentioned. I have also added a second table showing the relative humidity for the same stations at the same dates.

Thermometer, January, 1875.

Date.	Salt Lake C.	Virginia City.	Cheyenne.	Denver.	Pike's Peak.	North Platte.	Dodge City.	Bismark.	Ft. Sully.	Yankton.	Pembina.	Breckenridge.	Omaha.	Ft. Gibson.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
3.1	27	26	22	32	— 4	3	1	—16	— 9	— 7	—20	—22	1	32
3.2	41	— 5	2	40	— 2	4	4	— 5	— 1	0	—12	— 9	6	33
3.3	32	— 7	— 8	3	— 5	— 3	1	—12	— 2	— 1	—17	—14	4	29
4.1	25	—12	—12	0	— 8	— 8	1	—15	—10	—10	—16	—14	— 1	15
5.2	28	— 2	— 2	4	0	5	9	— 5	3	4	—11	— 2	10	26
5.3	19	— 6	0	3	— 7	— 7	2	— 6	— 3	6	—10	— 4	8	26
6.1	14	— 8	— 4	—12	—13	—18	— 9	—18	—10	—16	—24	—15	— 1	22
6.2	27	10	21	15	— 7	5	10	2	11	2	—12	— 1	15	30
6.3	23	2	9	6	—16	—10	— 2	—15	— 4	—11	—21	—16	6	29
7.1	23	16	13	10	—10	—17	0	—21	—12	—17	—17	—22	5	26
7.2	34	— 8	31	44	2	15	12	— 5	11	7	— 7	0	20	32
7.3	38	—22	— 3	39	— 1	25	22	—20	— 2	13	—15	— 5	19	24
8.1	36	—30	—23	—10	— 2	—18	—12	—27	—26	—22	—31	—30	—10	27
8.2	31	—24	—16	—14	0	—15	—12	—27	—21	—19	—30	—27	—15	7
8.3	23	—28	—37	— 4	— 6	—16	—10	—26	—19	—31	—33	—29	—15	— 3
13.1	18	—44	—23	—22	—11	—22	—19	—33	—26	—23	—28	—30	—17	8
13.2	24	—35	— 1	—11	— 2	—13	—13	—25	—21	—20	—19	—20	—11	13
13.3	21	—40	—13	—10	— 3	—14	—14	—28	—23	—24	—17	—28	—14	8
14.1	34	—35	—11	—14	1	—13	—14	—30	—27	—25	—28	—30	—13	2
14.2	43	—22	— 1	— 4	8	— 6	— 9	—15	— 6	—12	—15	—12	— 5	16
14.3	43	—26	24	1	5	—11	— 3	—15	—10	— 7	—23	—26	— 6	11
15.1	32	—23	28	43	6	— 8	6	—22	—10	—10	—14	—12	— 6	9
15.2	26	—18	5	10	12	— 1	6	—12	— 7	— 4	—10	— 4	9	39
15.3	23	—27	— 6	13	10	— 4	— 2	—22	—10	— 8	—20	—23	1	29

Relative Humidity, January, 1875.

Date.	Salt Lake C.	Virginia City.	Cheyenne.	Denver.	Pike's Peak.	North Platte.	Dodge City.	Bismark.	Ft. Sully.	Yankton.	Pembina.	Breckenridge.	Omaha.	Ft. Gibson.
3.1	77	77	72	30	100	73	71	68	56	59	100	81	100	89
3.2	30	66	100	28	100	87	74	63	52	56	75	68	52	90
3.3	60	63	100	73	100	69	71	75	67	68	69	82	100	89
4.1	63	54	100	69	100	58	71	47	54	54	70	85	100	83
5.2	44	69	67	100	100	100	78	26	46	73	77	68	68	63
5.3	54	81	100	19	100	63	72	61	66	76	77	83	100	88
6.1	64	61	80	50	73	66	58	34	54	69	51	85	..	95
6.2	77	40	39	14	59	75	58	44	78	58	50	67	65	59
6.3	73	72	57	52	70	54	69	42	65	72	61	85	76	68
7.1	73	66	61	38	100	68	69	0	50	68	69	80	87	82
7.2	69	61	48	9	100	82	80	63	40	65	80	70	77	60
7.3	46	24	100	38	100	75	72	100	67	71	100	91	84	74
8.1	45	43	100	77	100	67	50	47	..	59	100	90	100	88
8.2	71	59	73	100	100	42	50	48	..	65	100	85	..	80
8.3	60	49	100	82	100	40	54	0	..	62	100	85	..	52
13.1	68	0	..	100	100	60	30	0	..	57	..	82	..	78
13.2	61	32	84	0	100	47	52	53	..	64	65	64	..	46
13.3	71	..	47	54	100	72	45	45	..	57	68	85	..	68
14.1	61	30	76	100	100	74	72	0	..	53	..	83	..	72
14.2	50	63	68	64	100	61	66	42	57	74	71	67	82	33
14.3	50	54	60	71	100	76	66	100	77	79	59	85	100	60
15.1	84	36	67	21	100	79	52	60	54	76	72	85	88	78
15.2	52	39	75	17	100	68	52	50	59	65	54	66	67	37
15.3	73	52	61	44	100	64	67	..	52	58	64	85	85	89

These observations show considerable changes of temperature at Denver, but they do not show the entire range of the thermometer, and they give no adequate idea of the suddenness of the changes. We perceive that between 11 P. M., January 14th, and 7 A. M., January 15th, the thermometer at Denver rose 42°. We also perceive that the relative humidity fell from 71 to 21. The wind, which had previously blown from the northeast with a velocity of 3 miles per hour, at 9 P. M. (Denver time) veered suddenly to southwest with a velocity of 12 miles per hour. These three circumstances, viz: the direction of the wind, the dryness of the air and its high temperature, prove beyond doubt that this air came from the west side of the Rocky Mountains. On the previous day the temperature at Salt Lake City was 43°, and the relative humidity was 50°. An area of low pressure passed over San Francisco, January 14th about 4 P. M. During the following night the center passed near Salt Lake City, and at 4 P. M., January 15th, the center was near Leavenworth, having traveled about 1,400 miles in twenty-four hours. It was this storm which brought the air from the west side of the Rocky Mountains over to Denver. The vapor contained in this air would be mostly precipitated on the west side of the Rocky Mountains, so that it would descend on the east side deprived of its moisture and with a temperature above that which prevailed in the Salt Lake basin, on account of the latent heat liberated in the condensation of the vapor. This warm and dry air supplanted the cold air which previously prevailed at Denver, and which still prevailed at neighboring stations east and north of Denver. A similar change, but of less magnitude, occurred at Cheyenne a little before the change at Denver, while at Dodge City and Omaha the change was still less, and at stations further north the change was scarcely appreciable. After the center of low pressure had passed Denver, the northeast wind returned and brought back the cold air which had constantly prevailed at stations not very distant. A similar change occurred at Cheyenne, apparently at about the same hour. Thus we see that in winter, during periods of extreme cold on the east side of the Rocky Mountains, when the temperature at Denver sometimes sinks more than 20° below zero, there prevails in the Salt Lake Basin an average temperature of about 30°; and when by changes of atmospheric pressure this air is carried over the mountains it may reach Denver with a temperature of 50°, resulting from a precipitation of its vapor on the mountains. We then find a mass of air having a temperature of +50° in close proximity to a mass of air having a temperature of —20°, and by the movements of the atmosphere attending the progress of a great storm these different masses of air may be brought

successively over the same station, causing a change of temperature of 50° in a single hour.

The other cases of sudden change above enumerated admit of similar explanation. During January 7th there was a great rise of the thermometer at Denver, accompanied by a dry wind from the southwest. The next morning the thermometer fell suddenly with a wind from the northeast, which brought back the cold air which steadily prevailed at stations in the north. This change also accompanied the progress of an area of low pressure, which was apparently central near Virginia City on the morning of the 7th, and was central at St. Paul on the morning of the 8th. This storm was accompanied by similar changes of temperature at Virginia City, Cheyenne, and the other stations within the area of low pressure, but at none of them were the changes as great or as sudden as at Denver, for the reason that Denver is most favorably situated for feeling the influence of the mountains. The stations of the Signal Service which are nearest to the dividing ridge of the Rocky Mountains are Denver, Cheyenne and Virginia City. On the West of Denver, at the distance of only 40 miles, rises a continuous mountain range of 12,000 feet elevation, while at Cheyenne the mountains are more distant and of less height, and near Virginia City the height of the mountains is still less.

On the morning of January 3d the wind at Denver blew from the West with a velocity of 12 miles per hour. The air was warm and very dry. Between 3 and 5 P. M. the thermometer fell suddenly with a north wind. Similar changes were experienced at Virginia City and Cheyenne, accompanied by an area of high pressure pursuing an area of moderately low pressure. The case of January 5th was more remarkable for the suddenness of the change of temperature than for the magnitude of the change, and resulted from the passage of an area of slight barometric depression.

Barometric minima cross the Rocky Mountains.

In former papers, particularly Nos. 8 and 9, I have shown that areas of low barometer coming from the Pacific Ocean frequently cross the Rocky Mountains and travel eastward across the United States. In order to investigate this subject more fully, I selected from the published observations of the Signal Service (Sept., 1872, to Jan., 1875, and Jan. to May, 1877,) all those cases in which the barometer at Corinne or Salt Lake City was at least 0·4 inch below its mean height for that month. [The observations at Corinne ceased March 19, 1874, and those at Salt Lake City commenced the next day.] These cases are shown in the following table, in which column 1st gives the number of the storm; column 2d the date of the observation;

Barometer 0·40 inch below the mean at Corinne and Salt Lake City.

No.	Date.	Barom.	Wind.	Rain 8 hours.	Low center.	First appearance.	Reached the Atlantic Ocean. Date.	Reached the Atlantic Ocean. Lat.	Wind on Pike's Peak.
	1872.								
1	Nov. 8.2	29·61	S. 19	·00	350 E.N.E.	Portland, Or.	Nov. 12	45°	
	8.3	·72	N. 30	·02	600 E.N.E.				
	9.1	·76	W. 4	·14	750 E.N.E.				
2	12.1	·72	N.W. 31	·08	200 E.	Portl., Or. & Virg. C.	Nov. 15	47	
	1873.								
3	Jan. 3.2	·62	S. 20	·00	120 N.	Portland, Or.	Jan. 6	48	
4	26.2	·63	S. 16	·43	80 N.	Portland, Or.	?	?	
	26.3	·59	N.W. 22	·03	Corinne.				
5	30.1	·64	Calm.	·00	300 W.N.W.	Portland, Or.	Feb. 5	45	
	30.2	·52	N. 7	·00	300 W.N.W.				
	30.3	·60	E. 4	Snow	580 W.N.W.				
	31.1	·65	S.W. 2	·33	580 W.				
6	Feb. 23.3	·52	N. 12	·00	250 W.	San Francisco.	Feb. 28	43	
	24.1	·49	N. 1	Snow	300 W.				
	24.2	·41	S. 26	·14	120 W.				
	24.3	·38	S.W. 20	Rain	200 W.				
	25.1	·53	S. 5	·24	50 W.				
7	March 6.1	·68	S. 20	·00	470 N.E.	Portland, Or.	March 9	45	
8	April 2.3	·47	S. 11	·00	120 N.	Portland, Or.	?	?	
9	Sept. 25.1	·59	S. 8	·00	480 N.	Portland, Or.	?	50+	
	25.2	·60	S.W. 22	·00	680 E.N.E.				
	25.3	·63	N. 24	·00	710 E.N.E.				
10	26.3	·62	N. 14	·00	175 W.	San Francisco.	Sept. 29	50	
11	Oct. 7.1	·71	N. 14	Rain	400 N.	Portland, Or.	Oct. 12	44	
12	Dec. 7.1	·61	S. 5	·16	100 W.	Portland, Or.	Dec. 9	45	S.W. 18
	7.2	·61	S.W. 6	·11	Corinne.				S.W. 32
	1874.								
13	Jan. 2.1	·62	S. 12	·03	700 N.E.	Ft. Benton.	Jan. 5	45	W. 40
	2.2	·22	S. 20	·00	700 E.N.E.				S.W. 20
	2.3	·58	S. 2	·04	700 E.				S.W. 30
14	16.2	·60	S. 10	·00	350 N.W.	Portland, Or.	Jan. 20	45	W. 18
	16.3	·67	E. 2	·00	560 N.E.				W. 50
	17.1	·63	S. 2	·00	800 N.E.				W. 30
	17.3	·53	S.E. 2	Snow	700 E.N.E.				S.W. 20
15	19.3	·64	S. 20	·00	70 N.	Portland, Or.	Jan. 23	45	S.W. 10
	20.1	·59	W. 10	·00	130 N.				W. 20
16	Feb. 11.3	·56	W. 12	·00	770 E.	Portland, Or.	Feb. 14	49	S.W. 26
	12.1	·55	Calm.	·00	950 E.				W. 16
	12.2	·53	S. 20	·00	250 N.				W. 25
	12.3	·56	S. 20	Snow	500 N.W.				W. 20
17	18.1	·59	S. 12	Snow	600 E.N.E.	Portl., O. & Ft. Bent.	Feb. 20	47	S.W. 16
	18.2	·61	S. 4	·41	700 E.				S.W. 20
18	March 16.1	·45	Calm.	Snow	600 E.N.E.	Portl., O. & Virg. C.	March 20	50	W. 24
19	April 11.2	·51	S. 17	·00	200 N.N.W.	San Francisco.	April 15	48	S.W. 28
20	Oct. 23.2	·58	S. 12	·00	Salt Lake C.	Bismark.	Oct. 28	47	S. 11
	24.2	·61	S. 12	·05	470 E.N.E.				S.W. 52
	24.3	·56	S. 4	·00	700 N.E.				S. 60
21	Nov. 6.2	·50	N.W. 15	·02	700 E.N.E.	Portland, Or.	Nov. 10	48	S.W. 60
22	21.2	·45	S. 12	·00	700 E.N.E.	Bismark.	Nov. 24	50	S.W. 32
	21.3	·41	S.W. 8	·00	700 E.N.E.				S.W. 28
	22.1	·54	Calm.	·00	840 E.N.E.				N.W. 65
23	Dec. 26.2	·67	N.W. 10	·05	Salt Lake C.	Portland, Or.	Dec. 29	47	S.W. 12
	1875.								
24	Jan. 11.2	·53	Calm.	·22	350 E.	Portl., O. & Virg. C.	Jan. 14	48	S.W. 25
	1877.								
25	Jan. 10.2	·62	S. 4	·02	580 E.	Ft. Sully.	Jan. 13	43	W. 24
	10.3	·67	N.W. 12	·00	600 E.				N.W. 10
26	14.2	·59	S.E. 3	·01	650 E.	San Diego.	Jan. 16	45	S.W. 7
27	16.2	·60	E. 4	·00	420 N.W.	Portland, Or.	Jan. 21	48	W. 38
	16.3	·56	S. 8	·00	500 N.W.				W. 58
	17.1	·62	S. 16	·00	600 N.W.				W. 54
28	Feb. 23.2	·63	S.E. 4	·00	Salt Lake C.	Portland, Or.	——	—	S.W. 10
29	March 2.2	·47	S. 4	·23	320 E.	Portland, Or.	March 5	47	W. 30

column 3d the height of the barometer; column 4th the direction and force of the wind; column 5th the rainfall during the preceding 8 hours; column 6th the direction and distance of the low center from the place of observation; column 7th the station where the low center first made its appearance; column 8th the date at which the low center reached the Atlantic Ocean; column 9th the latitude of that point; and column 10th the direction and force of the wind on Pike's Peak at the date given in column 2d.

It will be noticed that the highest velocity of the wind at Corinne and Salt Lake City was 31 miles per hour, and the average velocity at the dates mentioned was less than 11 miles per hour. Southerly winds were three times as frequent as northerly winds. In only six of the cases did the wind blow from any eastern quarter, and its greatest velocity from this quarter was four miles per hour.

The amount of rain or snow attending these storms was very small, the average during the eight hours preceding the dates of observation being less than 0·05 inch. In eight cases rain or snow is mentioned in the column headed "state of the weather," when no entry is made in the column headed "rainfall."

In a few cases the low center appears to have passed directly over the station of observation, but generally it passed a little north of Salt Lake, and in no case did it pass south of it. Of the twenty-nine storms here enumerated, the stations at which the first indications of the low area are noticeable are as follows:

Portland, Or.,	17 cases.	San Diego,	1 case.
Portland, Or., & Virginia City,	3 cases.	Fort Benton,	1 case.
Portland, Or., and Fort Benton,	1 case.	Bismark,	2 cases.
San Francisco,	3 cases.	Fort Sully,	1 case.

In twenty-one of these cases the low appeared first at one of the stations on the Pacific coast, and we may reasonably infer that it came from the Pacific Ocean. In four other cases the low appeared simultaneously at Portland, Or., and Virginia City or Fort Benton, and it is probable that these storms came from the Pacific Ocean, but came from a latitude north of 50°, so that they appeared in the United States on both sides of the Rocky Mountains at about the same time. There remain only four cases, viz: Nos. 13, 20, 22 and 25. In these cases the disturbance apparently originated on the east side of the Rocky Mountains and thence extended to Salt Lake and the Pacific coast. In none of the cases did the low appear to originate between the Sierra Nevadas and the Rocky Mountains.

In all but three of these storms the low area can be traced to the Atlantic Ocean, which it reached in a latitude between

43° and 50°, averaging about 47°. No. 9 moved northward beyond our stations of observation, and probably reached the Atlantic Ocean somewhere north of lat. 50°. No. 4 apparently moved southward toward the Gulf of Mexico. Nos. 8 and 28 apparently declined soon after the dates given in column 2d, and cannot be satisfactorily traced to the Atlantic Ocean.

The following general conclusions seem to follow from the preceding observations:

1. No great barometric disturbances originate in the Salt Lake Basin.

2. Nearly all the great barometric disturbances experienced in the Salt Lake Basin come from the Pacific Ocean, and they generally come from the northwest.

3. Nearly all the great barometric disturbances experienced in the Salt Lake Basin can be traced to the Atlantic Ocean. They generally meet it near lat. 47° and occupy from two to six days in the passage, making an average of 3½ days, which corresponds to a movement of about 700 English statute miles per day.

There is a noticeable uniformity in the direction of the winds on Pike's Peak at the date of the preceding observations. The winds were generally from the west or southwest, and in no case from north, northeast, east or southeast. The average direction of the winds on Pike's Peak, as determined from the observations of five years, is N. 75° W. The average of the directions in the preceding table is S. 65° W., differing 40° from the mean direction. This result indicates that at the time of the preceding observations there was some cause in operation which deflected the winds from their average course. If we suppose that the abnormal winds on Pike's Peak are governed by a center of low pressure, according to the same law as the surface winds, then we may infer that in 27 of the preceding cases the position of this low center corresponded nearly with that observed at stations nearer the level of the sea. In five of the cases the low center appears to be somewhat northwest of that observed at the other stations; in one case it was somewhat north, in one case it was west, and in two cases it was east of the low center observed at the other stations.

These results accord reasonably well with those found in my tenth paper for Mount Washington, and seem to indicate that at great elevations the winds occasionally circulate about a low center as they do near the level of the sea; but the position of this low center at the height of 14,200 feet sometimes differs considerably from the low center prevailing at the surface of the earth, and this deviation is generally toward the northwest.

There are three methods by which the progress of areas of low pressure across the Rocky Mountains may be readily indi-

cated. One is by curves representing from day to day the fluctuations of the barometer at the various stations, as shown in Plates I and II, accompanying my ninth paper. These curves indicate distinctly the eastward progress of low areas, but they do not show the center of a low area, and therefore do not indicate the exact path of the low center. There are two methods by which the position of the center of a low area can be traced from day to day, viz: by *isobaric* lines or *isabnormal* lines. If we employ isobaric lines, it is requisite that the observations at all the stations should be carefully reduced to sea level, and, in the case of the mountain stations, this involves the decision of questions respecting which meteorologists may be expected to differ. But after reducing the observations to sea level by any of the methods which different meteorologists may be supposed to advocate, we still find evidence that areas of low pressure frequently travel from the Pacific Ocean across the Rocky Mountains and thence eastward toward the Atlantic. The isobars drawn to represent the observations at the mountain stations are seldom as symmetrical as they are over a level country. This may be due partly to the obstacles which the mountains present to a system of circulating winds, and partly to the influence of the heavy precipitation of vapor upon the mountains. In many cases, however, the isobars show considerable symmetry, and this is most noticeable in very violent storms. Plate II exhibits the isobars for April 11, 1874, at 4:35 P. M. This is a storm which was noticed in my ninth paper, and a map was then given showing the isobars for April 12th at 7:35 A. M. By comparing the two maps it will be seen that during this interval of fifteen hours the isobars retained nearly the same general form, and the distance between the two low centers remained almost exactly the same, the two systems of isobars, with the intermediate high area, having been transferred eastward about 420 miles, being at the rate of 28 miles per hour. While, however, the second low center followed nearly in the track of the first low, and maintained nearly the same distance during the whole time of crossing the United States, the high center moved from Lake Superior to Norfolk, Va.; that is, from northwest to southeast, maintaining during the whole time nearly the same pressure.

The direction of the winds, April 11th at 4:35 P. M., west of the Mississippi river, corresponded with what is usually observed about a low center, with the exception of Portland, Or., and Virginia City. The latter observation seems to indicate that the center of the low area was further north than is represented upon the map; but we find frequent anomalies in the direction of the winds at the mountain stations, as will be

seen from the map which accompanied my ninth paper. These anomalies indicate that while a regular system of circulating winds may prevail above the tops of the mountains, this system is obstructed in the valleys between the mountain ridges, so that here the direction of the wind may be opposite to that which prevails above the mountains.

If we attempt to trace the progress of storms across the Rocky Mountains by curves of isabnormal pressure, we have no occasion to reduce the observations to sea level; nevertheless, when we aim at great precision we find a difficulty in comparing mountain stations with stations at a lower level, inasmuch as the barometric fluctuations generally diminish as we rise above the level of the sea. In order to find what correction is due to this cause I determined the mean monthly range of the barometer at all the stations of the Signal Service west of the Mississippi river according to the published observations (now amounting to thirty-five months). The following

Mean monthly range of the Barometer.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Portland, Or.	1·15	0·95	0·82	0·85	0·62	0·54	0·33	0·43	0·56	0·62	0·98	1·04	0·74
San Francisco	0·81	·70	·51	·54	·37	·41	·39	·35	·37	·48	·51	·64	·51
San Diego	0·46	·56	·41	·42	·31	·29	·27	·25	·35	·37	·45	·44	·38
Virginia City	0·88	·82	·66	·61	·58	·51	·35	·34	·66	·66	·85	·86	·65
Corinne	1·19	·93	·83	·96	·67	·47	·42	·35	·66	·60	·81	·77	·72
Cheyenne	0·78	·71	·76	·71	·64	·48	·42	·40	·69	·71	·79	·75	·65
Salt Lake City	·77	·69	·75	·39	·48	·53	·36	·32	·66	·79	1·00	·84	·63
Denver	·85	·77	·81	·77	·69	·54	·46	·43	·76	·72	·84	·76	·70
Pike's Peak	·65	·60	·69	·49	·68	·50	·38	·34	·41	·65	·75	·87	·58
Santa Fe	·72	·59	·66	·53	·41	·43	·39	·24	·41	·51	·61	·63	·51
Ft. Benton	1·23	·92	·99	1·07	·79	·62	·68	·63	1·01	·87	1·22	1·00	·92
Bismark	1·32	1·17	·97	1·14	1·29	·86				1·30	1·84	1·44	
Ft. Sully	1·50	1·37	1·45	1·13	1·11	·90	·90	·82	1·16	1·24	1·21	1·31	1·18
Yankton	1·44	1·38	1·34	1·13	1·03	·80	·76	·69	1·15	1·13	1·41	1·15	1·12
Omaha	1·36	1·39	1·37	1·09	·91	·71	·71	·57	·87	1·05	1·39	1·16	1·05
North Platte	1·41	·97	1·30	1·25	1·10	·78				1·29	1·65	1·13	
Dodge City	1·45	·86	1·29	1·00	·91	·88				1·10	1·33	1·11	
Pembina	1·45	1·27	1·25	1·07	1·08	·80	·78	·73	1·06	1·00	1·36	1·32	1·10
Duluth	1·35	1·38	1·24	1·12	·95	·98	·67	·63	·88	1·11	1·44	1·33	1·09
Breckenridge	1·42	1·32	1·34	·99	1·11	·87	·76	·62	·97	1·18	1·42	1·32	1·11
St. Paul	1·27	1·39	1·34	·92	·91	·80	·63	·61	·91	1·12	1·34	1·29	1·04
La Crosse	1·20	1·43	1·25	·95	·87	·75	·63	·59	·84	1·14	1·30	1·34	1·02
Dubuque	1·14	1·32	1·24	1·06	·75	·66	·65	·61		1·24	1·45	1·21	
Davenport	1·14	1·44	1·21	·99	·77	·61	·55	·55	·73	1·00	1·32	1·17	·96
Leavenworth	1·30	1·34	1·25	1·07	·77	·61	·61	·53	·82	·97	1·29	1·13	·97
St. Louis	1·17	1·20	1·19	·94	·71	·56	·51	·55	·67	·84	1·22	1·08	·89
Cairo	1·14	1·02	1·16	·91	·58	·52	·45	·45	·48	·70	1·07	·89	·78
Ft. Gibson	1·28	1·06	1·04	·95	·77	·49	·54	·46	·63	·91	1·11	1·02	·86
Memphis	1·05	·97	1·01	·88	·58	·45	·43	·38	·43	·59	1 02	·91	·73

table shows the results obtained. The first three stations are situated near the Pacific coast; the next seven stations are situated among the mountains; the next seven stations are situated east of the Rocky Mountains at elevations between 1,000 and 3,000 feet; and the last twelve stations are elevated less than 1,000 feet above the sea.

I next proceeded in the manner described in my twelfth paper, page 90. I determined the mean annual range of the barometer at a point on the Pacific coast, and also the range at a point in the Mississippi valley, each having the same latitude as one of the mountain stations. Between the two results thus obtained I interpolated a value corresponding to the difference of longitude between the given station and the two points above named. The result is regarded as the barometric range at the level of the sea directly under the given station. A similar computation was made for each of the mountain stations, and the ratio of the observed range to the range thus computed was determined. This comparison indicates that the barometric fluctuations observed at Salt Lake City should be increased by 8 per cent, and those at the other mountain stations, viz: Virginia City, Cheyenne, Denver and Santa Fe, should be increased by 25 per cent. I have drawn the isabnormal curves for a large number of cases, employing these corrections, and find that the curves are generally more symmetrical than when no correction is applied.

In preparing the materials for this article I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College of the class of 1871.

ART. II.—*On the Geological relations of the Limestone Belts of Westchester County, New York;* by JAMES D. DANA.

WESTCHESTER County is comprised within the Green Mountain region; and my studies of the County have been carried on with special reference to the subject of Green Mountain geology.[1]

In commencing my observations in Western New England, I had in view the following points:

(1) To determine the limits of the series of rocks associated conformably with the limestone of the Green Mountain region; and (2), since the limestone is of Lower Silurian age as is shown by its fossils, to determine, consequently, the limits of the Lower Silurian in the Green Mountain region.

(3) To ascertain the kinds of metamorphic rocks constitu-

[1] For my former papers, see this Journal, third Series, iv, 362, 450, 504; v, 47, 84; vi, 257, 1872, 1873; xiii, 332, 406; xiv, 36, 132, 202, 257, 1877; xvii, 375; and xviii, 61, 1879; xix, 191, 1880.

ting these Lower Silurian beds; and (4), to ascertain, consequently, how far the kinds of crystalline rocks found in the conformable series can be used as a test of geological age.

As the fossils of the limestone had been discovered only in Vermont, it was required, in order to extend the conclusions to the rest of the Green Mountain region, that the Vermont limestone should be proved to be the same stratigraphically with that of the region to the south; and this was done by ascertaining (1) the essential continuity of the limestone from the north to the south and south-southwest, and (2) its association with similar rocks from north to south, under similar stratigraphical relations; and finally (3), by the discovery of Lower Silurian fossils in the part of these belts of limestone that reach into and beyond Dutchess County, and also in the associated Taconic schists of that County.[2]

By these means, it has been shown that the schists of the Taconic range, the limestone belts on either side, and various conformable schistose rocks and limestone belts farther east and west, are comprised within the Lower Silurian formation, and that the whole series was displaced together in the upturning and metamorphism by which the Green Mountains were made.

The demonstration in my former papers does not reach into the region south of the limits of Dutchess County and of the corresponding parallel in Connecticut. I present now observations on the same points from this more southern region in the State of New York, leaving the discussion of the facts from Connecticut for another paper. I have not undertaken to work up thoroughly Westchester County geology, but simply so much of it as bears directly on the great question in view.

In my paper "On the Hudson River age of the Taconic Schists," published in this Journal in 1879, the accompanying map exhibits the fact that the Lower Silurian schists and limestones of Dutchess County have their southern limit against or among the Archæan rocks of the Highland range. The Highland Archæan area extends eastward from the Hudson, over Putnam County, to a distance less than twenty miles, falling short of the New England boundary by four or five miles—the rocks at Brewster, west of and along the Harlem railroad being of the Highland character, even to the existence of a great iron-ore bed, while those farther east are mostly distinct in kind and system. The extreme breadth of the area is about fifteen miles; but the outside rocks, just referred to, send prolongations through its supposed boundary, and cover part of its interior.

[2] T. Nelson Dale, this Journal xvii, 57, 1879; the writer, ibid., xvii, 375, and xviii, 61, 1879; W. B. Dwight, ibid., xvii, 389, and xix, 50, 451, 1880; R. P. Whitfield, ibid., xviii, 227, 1879.

Westchester County comprises all of Southern New York between Putnam County and New York Island; and thus it borders the southern side of the Putnam County Archæan, as Dutchess County does the northern. It resembles in its rocks that part of the Green Mountain region which now makes Western Connecticut. New York Island is topographically and geologically a portion of it.

The only published geological reports treating of the Geology of the county are that of Mather, in his Report on New York (1843), and that of Percival on the Geology of Connecticut (1842). Mather mentions the principal kinds of rocks, various localities for those that are of special or economical interest, and some stratigraphical facts. Many localities of limestone are given, and I have thence derived much aid in the study of the region. On his map the positions of several of the areas are laid down, but mostly with miles of inaccuracy. The report bears evidence of being compiled from the notes of the assistant geologist by one not familiar with the region. Percival's map of Connecticut gives the areas which lie near the Connecticut boundary, with the general correctness characteristic of his work.

In presenting my observations I will speak *first*, of the rocks; *secondly*, of the general distribution of the limestone areas or belts; *thirdly*, of the special positions and stratigraphy of the limestone areas; and *fourthly*, of the relations of the rocks to one another and to the Green Mountain system.

1. The Rocks.

The rocks are (1) the ordinary metamorphic rocks of the County, not calcareous; (2) Calcareous rocks or limestones; (3) Serpentine and other hydrous materials; (4) Augitic and Hornblendic rocks not included above.

(1.) *Ordinary metamorphic rocks of the County, not Calcareous.*

Of these metamorphic rocks, the prevalent kinds are micaceous gneiss, mica schist, ordinary gneiss, and hard feldspathic and granitoid gneiss. Besides these, and subordinate to them, there are hornblendic varieties of mica schist and micaceous gneiss, and hornblende schist. Granulyte is also found, especially in the northeastern part of the County, and in some places metamorphic granite.

In the mica schist and gneiss, both of the two common kinds of mica, the black (biotite) and the light-colored (muscovite) are usually present together;[3] but the black greatly predominates. True muscovite gneiss or muscovite mica-schist is

[3] The black may be in part lepidomelane, a point not investigated, as it requires a series of chemical analyses.

of rare occurrence. Blackish gray beds, owing their dark color to the very large proportion of black mica, often alternate with whitish or light-colored beds in which muscovite is the most abundant mica. Frequently, also, mica schist graduates into gneiss in the direction of the bedding as well as transverse to it. The distinction of gneiss from mica schist is, therefore, made often with difficulty, and the restriction of the latter term to kinds consisting of mica and quartz without feldspar is impracticable. The rocks of New York Island are good examples of the ordinary rocks of Westchester County, both as to kinds and their transitions.

Garnetiferous varieties of the mica schist and gneiss are common. A variety of micaceous gneiss in Singsing, contains large elliptical crystallizations of muscovite. A *cyanitic* mica schist is met with on New York Island, as announced by Professor D. S. Martin.[4] A dark gray *fibrolitic* gneiss, containing some tourmaline has been described by Professor A. A. Julien, as occurring at New Rochelle.[5] (The minerals cyanite and fibrolite are alike in composition, they being chemically similar aluminum silicates, and differing only in crystallization.)

Hydromica schist, of the slightly crystalline variety, resembling closely a glossy roofing slate, occurs in the northwestern part of the County, north and northeast of Peekskill, on the borders of the Archæan of the Highlands. It is called talcose slate by Mather. Nothing nearer to argillyte (phyllyte) is found in the County. Across the Hudson River, in Rockland County, in the continuation of the same stratum, near Tompkins' Cove, the slate is very carbonaceous, as Mather's report states, and much of it is still less metamorphic in its aspect.

Quartzyte constitutes a stratum several hundred feet thick in the vicinity of the hydromica schist, north of Peekskill, as pointed out by Mather. But a large part of the rock in that region contains more or less feldspar, and often also mica in rather indistinct grains; looking either like an underdone micaless granite or granitoid gneiss. It is usually much jointed and without distinct bedding. The northern part of the mass, at the mouth of the river north of Peekskill, is a true siliceous quartzyte, fine-grained, and even in bedding; while on the southern side it graduates into the slate. It thus varies greatly in constitution, but in a way to make it certain, that, although so feldspathic in portions, the whole of it is one quartzyte formation. Further, it is evident, from the facts, that the quartzyte and slate are stratigraphically the same rock; one changing to the other, and taking the same positions with reference to an associated stratum of limestone. In the Rockland County

[4] Proc. Lyceum Nat. Hist. New York, i, and this Journal, II, iv, 237.
[5] Amer. Quart. Micr. J., Jan. 1879.

continuation of the formation (which extends for about two miles from Tompkins' Cove to Stony Point village, where the Mesozoic Red sandstone appears in force), the slate changes in places to a massive quartzyte, often containing much blackish slate material, and looking as if it had been made out of a mixture of mud and quartz sand, with at times some feldspar. Remembering that the making of beds of sand by moving waters involves the making of mud not far away, such transitions are no occasion for surprise; and in view of the fact that the Highland Archæan is close at hand—not three miles distant—the presence of feldspar is intelligible.

A bed consisting chiefly of radiated actinolite occurs west of Kingsbridge, north of the Harlem River. It is so deeply decomposed at the exposure that I failed to obtain a specimen from the unchanged bed. The looseness of texture shows that something has been removed, and this is probably, in part at least, calcareous material; and if so the bed should be classed with the limestone beds. This locality is by the west side of the eastern of two bridges, near the Spuyten Duyvil Iron Foundry, and stratigraphically but a short distance from the belt of limestone of the northern end of New York Island.

The metamorphic strata stand every where at a high angle—seldom under 40°, very frequently above 80°. The bedding, while generally regular in its strike or direction, is often contorted, especially to the east and north, showing that much torsion accompanied the upturning. As usual elsewhere in metamorphic regions, the limestone beds (owing to the stiff unpliant nature of limestone) are at times very various in strike when the schists of the vicinity have the bedding even or nearly so. This great amount of torsion has a sufficient explanation in the fact that Archæan rocks bound the County on the north; and, moreover, along the northern half of the County they are not far distant to the west of Hudson River, not a dozen miles intervening in the latitude of Singsing. No true unconformability between the limestone and other strata has been observed, though local cases of non-conformity occur that are due to the contortions and accompanying faults.

Granite veins are common both in the gneiss and mica schist, though most numerous in the former; and they are often of very large size. They usually consist of coarsely crystallized orthoclase and quartz, with some muscovite-mica and albite or oligoclase. Black mica is often sparingly present, and sometimes prominently so; and when present the plates are frequently of oblong-rectangular outline. The most common accessory minerals are garnet and black tourmaline; beryl or columbite I have not found. As in other regions of highly crystalline metamorphic rocks, veins of quartz are not common.

The rock that adjoins a belt or stratum of limestone is commonly a mica schist or micaceous gneiss in which black mica abounds; or, at times, hornblendic varieties of these rocks, or else hornblende schist; and the beds are not unfrequently pyritiferous. But the rock may also be ordinary gneiss, or a light-colored feldspathic gneiss; or it may consist of intercalations of these with the more micaceous kinds, and in the northeastern part of the County it is in some places granulyte. More remote from the limestone strata, the rock is generally less micaceous, and either ordinary gray gneiss, or hard feldspathic and thick-bedded gneiss.

This association of the limestone with rocks containing much black mica or hornblende is, in fact, association with rocks containing *much iron*:—an association which exists in similar cases throughout the Green Mountain region, and corresponding regions in the State of Pennsylvania and others farther to the southwest; as is indicated by the rusting tendency of the schists in the vicinity of limestone beds, and, still more, by the occurrence of great limonite beds made from the iron of the limestones and adjoining schists.

Furthermore, this quality of these metamorphic schists is a consequence of the ferruginous character of the original sedimentary beds underlying or overlying the limestone strata. The iron of those sediments went, for the most part, at the time of metamorphism, to make the black iron-bearing mica or hornblende, the rest of it entering mainly into pyrite and, sometimes, garnet. The distinction between these schistose micaceous rocks and a hard thick-bedded feldspathic gneiss is, to a large degree, therefore, the equivalent of that in regions of sedimentary rocks between highly ferruginous and slightly ferruginous beds, and hence it is not necessarily of much geological importance. This fact, which is abundantly established by the frequent abrupt gradations in such rocks from extreme micaceous to feldspathic kinds, teaches that it is unsafe to infer from the looks or composition alone, that the hard, gray feldspathic gneisses are really the more ancient. Moreover, the preponderance, in such schists, of biotite over muscovite is not due to a deficiency of potash in the original sediments, for each is a potash-mica, and contains ordinarily 8 to 9 per cent of the alkali, or three-fourths of the amount that exists in a potash feldspar; but chiefly to the presence of iron. Hornblende has been formed where iron existed without enough of potash for making mica. The facts also show that the foliation of such gneisses is a consequence of the original bedding.

(2.) *Calcareous Rocks.*

The limestone of the County is, in general, coarsely crystalline, and of a white to grayish-white color, and in many places it is quarried for use as an architectural marble. But in the northwestern part of the County, in the vicinity of the Archæan, it is feebly crystalline, and in part has the gray color and texture of the unaltered rock. The absence of crystallization is so marked in the part of the northwestern belt which occurs on the west side of the Hudson River, at Tompkins' Cove, that much of it, especially in the western beds toward the Archæan, is like ordinary gray and unaltered limestone, so that if the rock is without fossils—a point yet to be made certain—the reason is not their obliteration by metamorphism.

According to the few analyses that have been published, the rock is a magnesian limestone or dolomite. Iron replaces in some beds a portion of the magnesium; and when so the blocks of "marble" show it by becoming rusty in color after exposure. Iron is not unfrequently present also in pyrite (FeS_2) another source of rust and destruction, and less frequently in pyrrhotite (Fe_nS_n); chalcopyrite (or copper pyrites) is of occasional occurrence. Scales of mica, mostly of the species muscovite, are often distributed through the beds, and such micaceous limestones graduate in many places into calciferous mica schist. The calcium-magnesium silicate, tremolite (or white hornblende) is very common in bladed crystals and fibrous or asbestiform masses, and sometimes is the chief constituent of a bed. Green hornblende in minute rounded crystals are occasionally found disseminated through the limestone; and radiated actinolite is at times a constituent, if the bed referred to on page 25, is really a calcareous one. White to grayish green pyroxene has been reported from a few localities, as in the Singsing limestone, (especially its southern portion in Sparta,) and in the limestone of New York Island near 208th street, localities mentioned by Mather, and the latter from the observations of Professor Gale. I have not succeeded in my attempts to verify the fact at either place.

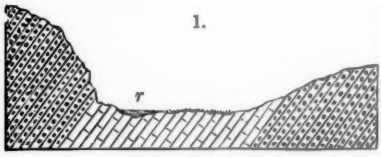
Chlorite in scales is distributed through some limestone beds in the southern part of the County, as, for example, at a locality a mile northeast of Central Bridge, over Harlem River, and in Eastern Morrisania. Graphite is sometimes sparingly present, and more rarely small crystals of sphene. Apatite is found only in an occasional minute crystal. Chondrodite has not been observed.

Much of the limestone crumbles on exposure, making sandy hills of its outcrops; but this is true of the same rock in Western Connecticut and Massachusetts.

The Westchester County limestone beds are much thinner

than those of Dutchess County or Western Connecticut. This may be a consequence of their having been subjected to hotter silicated solutions in the metamorphic process, that is, to intenser metamorphic conditions, such as the coarse crystallization of the rocks would have required. But while there may be doubt as to the thinning in particular cases by this means, there is none as to the dissolving power of such hot silicated waters, and the tendency of their action to substitute silicates for the carbonate. Tremolite and light-colored pyroxene, as long since suggested by the writer,[6] are among the products that would naturally come from this action—dolomite being a calcium-magnesium carbonate, and the minerals mentioned being silicates of the same bases. The fact that experiment has obtained pyroxene in crystals by heating together the ingredients favors the conclusion. The tremolite of the more southern portion of the Singsing limestone area often makes a thick envelope about portions of limestone, showing that it was formed between fragments out of their material. If the dolomite is a ferriferous variety, the action might, in the same way, produce green hornblende or actinolite, or green pyroxene. The only other magnesian silicate often present, and abundant in the adjoining schists, is biotite; and this could have been produced only where iron also was at hand. Chlorite might have been formed under nearly the same conditions as biotite. Whatever the limestone beds lost through the action of the silicated solutions must have gone either to the making of these silicates or of other more soluble silicates; for muscovite contains but one per cent or less of calcium or magnesium, and orthoclase none of either of these elements.

Westchester County, like the Green Mountain region generally, owes much as regards its topographical features to the limestone belts. These belts, because of the easy erosion of limestone, have determined the courses of river-valleys, and of lines of marshes along such valleys, and many a lake has been located by them. The beds of this soft rock stand nearly vertical, thus favoring the excavation of deep channels. The valleys are sometimes abrupt on both sides, but usually have one side high, precipitous and rocky, and the other gently sloping; and this is largely due, in connection with the erosion, to the pitch or dip of the beds. The annexed figure illustrates the



[6] J. D. Dana, on the Composition of Corals, and the production of the phosphates, aluminates, silicates, and other minerals of crystalline limestones, by the metamorphic action of hot water, in this Journal, I, xlvii, 135, 1844. See also Bischof's Lehrbuch Chem. Phys. Geol., 2nd edit., Engl. Transl., 1866, iii, 28.

ordinary facts. The underdipping side of the limestone area is the steep side of the valley, because of the undermining which the position of the limestone stratum favored; and, for the same reason, the river channel (*r*) is made to hug the same side, and leave the other for wide strips of marshy land, with sometimes pond-like broadenings of the stream. This point was observed by Percival in his survey of Western Connecticut and the adjoining portions of New York State.

But the pitch of the beds has not been the only cause of this form of the valleys. The throw of the waters against the right bank of a stream (the western if flowing south, or northern if flowing west), in consequence of the earth's rotation, must have had its effects, and may account for the cases in which the western side is the steep one, notwithstanding a vertical or even a high eastern pitch. During the progress of the Glacial era, the subglacial streams would have felt this throw and worked in accordance with it; and afterward, when the Glacial flood, from the melting, was at its height, the rushing waters would have swept the earth away from the same side, and transferred much of it to the opposite.

Not unfrequently the profile of a valley and its marsh at bottom are, for long distances, all the evidence there is in sight to suggest the presence of limestone beneath; and hence come uncertainties as to the true limits of a limestone belt, which only deep diggings through the alluvium or stratified drift of the valley can remove.

The mapping of the limestone areas has other difficulties in consequence of the frequent intercalations of beds of mica schist or gneiss. Percival includes in his areas the interstratified schists; and this method is often unavoidable, except on a map of very large scale, after a careful survey. But not even the utmost thoroughness would always secure accuracy of details in this respect, because of the prevailing cover of marshes and ponds. But this alternation is sometimes only apparent; that is, in place of two distinct limestone strata with an intervening stratum of schist, there is often *one folded* stratum of limestone whose enclosed schist (mica schist or gneiss) has come out to view through denudation. If the fold is one having a horizontal axis, the denudation, if alike in all parts, would reduce it to two limestone bands and one of schist intermediate; but if its axis is inclined—the common fact—the two limestone bands may be separated by schist only for part of its length. This point is illustrated by several of the belts, and is explained in connection with the description of belt No. 1 beyond, and further exhibited on the map of Westchester limestone areas, accompanying this memoir.

(3.) *Serpentine and other Hydrous Minerals.*

The limestone areas, at several widely distant points, are associated with or contain serpentine, with sometimes also talc and hydrous anthophyllite. It is embedded in small masses in the northwestern limestone area, or that of Canopus Hollow, at a quarry two and one-half miles north-northeast of Peekskill; more sparingly in the southern part of the Singsing area, which is near the central latitude of the County: and to the south, with hydrous anthophyllite; in eastern Morrisania, near 142d street; and also at some points on New York Island. It is (as has long been known) the chief constituent of large beds near New Rochelle and Rye, at both of which places the area is embraced, like the ordinary limestone belts, between conformable beds of micaceous gneiss.[7]

The New Rochelle serpentine area is on Davenport's Neck, a nearly north-and-south peninsula bordering on Long Island Sound. The outcrops occur over the northern half of the western portion of the peninsula, and near the middle of the northern shore. At the eastern end of the last mentioned exposure, the rock is mostly crystalline limestone; but the thickness of the limestone portion of the belt is uncertain because earth covers the next two hundred yards, and then succeeds the gneiss. In Rye, the serpentine area commences one mile north of the railroad station at Rye, and extends northward for over a mile and a half. The rock contains some limestone disseminated through it, and the removal of it by percolating waters has made its surface portions cavernous, and some parts light and porous. The associated limestone, both at New Rochelle and Rye, is dolomite, and partly, if not wholly, a ferriferous dolomite.[8]

The serpentine of these regions varies in color from pale green to blackish green, dark brownish green, brownish yellow and brick-red. Part of it at New Rochelle is whitish and translucent, resembling retinalite and deweylite. The fibrous variety, chrysotile, is also met with. The rock is much rifted, and impure with disseminated magnetite, talc, "hydrous anthophyllite," and other materials.

The propriety of classing these serpentine areas with those of limestone is sustained by the following considerations: (1.) The stratigraphical position accords with this view; (2) the presence of dolomite, disseminated through the serpentine rock or associated with it, favors it; and (3) the fact that the

[7] Mather's N. Y. Report, p. 462.

[8] For the facts as to the stratigraphical positions of the serpentine areas and the adjoining schists, see the remarks beyond on the areas, Nos. 5 and 6.

Mather mentions, in his N. Y. Report (p. 461), the occurrence of serpentine three or four miles southeast of White Plains. I have looked for the locality without success.

serpentine and other hydrous silicates originated from minerals that are common in the Westchester County limestone (dolomite) beds, and that this change has taken place in many beds that are still chiefly limestone, gives it support. The following are some examples under the last point:

The hydrous anthophyllite (first known from New York Island) was long since shown to be altered tremolite, the most common of the limestone minerals; and limestone has often been observed in close association with this hydrous mineral, or as the adjoining or containing rock. At the most important locality—between 57th and 63d streets on the western side of New York Island—Dr. Gale describes it as associated with serpentine and limestone.

The small serpentine masses, embedded in the limestone of Canopus Hollow (Sprout Brook Valley) referred to above, I have found to present sometimes the forms of a group of distinct crystals of tremolite; and the same is true with that of the Singsing limestone area. The New Rochelle and Rye serpentine is often largely made up of crystallizations of tremolite in all stages of alteration, from the unchanged mineral to amorphous serpentine; while other portions contain the allied mineral, actinolite, under the same conditions. Some of the silicates are changed also to talc, making pearly plates distributed sparingly through the serpentine. The dolomite has also participated in the change and been turned into serpentine. One piece of the serpentine obtained at New Rochelle looks like a pseudomorph after a large and fine crystal of pyroxene; but it is rough, and I am doubtful as to this origin. Mather, however, speaks of the occurrence of pyroxene with the serpentine of that locality; and it is possible that this mineral made part of the original material. It has already been stated that tremolite is abundant in the Westchester County limestone, and occasionally makes up the greater part of some beds. Actinolite is not common; but one bed of it has been mentioned (p. 25) as occurring just west of the Kingsbridge limestone.

The serpentine has also originated in part—how large a part is uncertain—from enstatite, another mineral of the hornblende family; and some, at least, of the talc has the same origin. Unaltered portions have the infusibility or near infusibility of this mineral, and show by their optical characters, as has been observed by Mr. G. W. Hawes, that the crystallization, unlike that of the tremolite, is orthorhombic. This mineral is yet unknown from any of the limestone beds or other rocks of the county, and, were it not for the tremolite and dolomite, would suggest other relations for the beds.

Many disseminated grains and masses of serpentine in the New Rochelle serpentine have the yellow and brownish yellow

colors of chondrodite, and look as if they had been derived from that mineral. But the cleavage of some of the large masses so colored, and other peculiarities, show that this idea is not tenable, and evince that the color has come from oxidized iron. The change to serpentine—a hydrous magnesian silicate—would have set free the iron in the minerals undergoing the alteration—whether actinolite, ferriferous dolomite, or tremolite (this last containing one-half to two per cent, and actinolite three to twelve per cent); and thence would have come by oxidation the limonite, which is the source of the color. But magnetite (Fe_3O_4) also occurs in much of the serpentine in disseminated grains, and this contains another part of the oxidized iron—a point well illustrated by the facts with regard to serpentine pseudomorphs at the Brewster (Tilly Foster) Iron Mine, in Putnam County, New York.[9]

In view of the facts with regard to the character of the limestone (dolomite) beds, and those of serpentine, we may deem it probable that the beds which now contain, or consist mainly of, serpentine, or of "hydrous anthophyllite," were (A) *originally* beds of uncrystalline limestone (dolomite); that (B) they became beds penetrated with tremolite, actinolite, and other mineral silicates, at the time of the first metamorphism of the limestone —and that this change in some cases may have gone so far as to use up the most of the limestone of a bed; further, (C) that these beds afterward underwent a later transformation, converting the tremolite and other magnesian silicates, and part of the remaining dolomite, into *hydrous* magnesian silicates, and mostly to serpentine. This later transformation was probably due to movements attending some subsequent disturbance of the region, by which, through friction, the heat was produced needed for making silicated solutions.

No large beds of limonite (or brown hematite, as it used to be called) have been found in connection with the limestone and adjoining schists of Westchester County. Such beds in other regions are seldom extensive except where the schists are the semicrystalline hydromica schists. In the serpentine region of Rye, limonite has resulted from the alteration of the serpentine rock, and the bed has been opened, though not with good prospects of profit. The limonite in this case has come chiefly from the oxidation of the iron of the ferriferous dolomite associated with the serpentine, and that of the disseminated magnetite.

[9] See the author's memoir on the serpentine pseudomorphs of the Tilly Foster Iron Mine, in this Journal, III, viii, pages 454, 455, 1874.

[To be continued.]

ART. III.—*Observations on Mount Etna;* by S. P. LANGLEY.

DURING the winter of 1878, in the course of a visit to Europe, I spent some time upon Mount Etna, and at the request of Captain Carlisle P. Patterson, the Superintendent of the United States Coast Survey, gave attention there to the character of the astronomical vision, in order to enable comparisons to be made with observations taken under similar conditions in our own territories. I have thought that in view of the present attention to mountain sites for observatories, the results might be of interest to others, and I have obtained the kind permission of the Superintendent to the publication of the following extracts from a report made to him on my return. It is proper to preface them by the request that the reader will remember that the observations are not the results of an organized expedition, but merely such as a single traveler, unprovided with large instrumental means, might attempt in a limited time.

The progress of modern optics is now furnishing observers with telescopes of a power which exceeds the capacities of our lower atmosphere for their constant employment. The obstacles to definition due to this atmosphere, and which increase nearly in proportion to the increase of optical power, have grown to be so nearly a barrier to any rapid progress, that attention has been much given of late to the conditions of vision, which it is very commonly supposed will be found to be best on mountain summits. On this point, however, we have scarcely any exact information, Professor Smythe's expedition to the Peak of Teneriffe, (see "An Astronomer's Experiment"); some interesting remarks by Professor Henry Draper on the Wahsatch Mts., (this Journal, vol. xiii, p. 89); and some incidental notes by temporary observers in the Himalayas, making the sum of our scanty knowledge. It seemed to me that I could best employ my limited time and means by selecting, as a station, a point generally admitted to be the most favorable of any in Europe, and there attempting to gather some sort of quantitative estimate of the degree of transparency and definition, to take the place of vague statement, and to give a kind of standard for comparison with sites in our own territory.

Very concurrent testimony points to the atmosphere of the shores and islands of the Mediterranean, and particularly of Sicily, as being on the whole superior to that of Northern Europe, and in Sicily, Mount Etna has not only long been distinguished for the extraordinary extent of the prospect, undisturbed by haze, but by its recent selection as a site for a mountain observatory by the Italian authorities guided by the competent judgment of Professor Tacchini. This was the

selected site for experiment, but instead of finding myself upon the ground in October, as I had intended, it was not until the 25th of December, that I finally ascended the mountain; when the lateness of the season brought bad weather, which made the opportunity for observation limited. According to local opinion, the air is, if anything, clearer in winter here than in summer, when it is not actually cloudy. However this may be, the chief drawback on observation was the number of stormy days, by which I mean that the character of the vision on those which were fine, seemed as good as that which any season could have furnished.

Etna is a mountain of great extent, its lower cultivated slopes being very gradual, so that for five or six miles of gentle ascent from its base, it is ringed with a zone of rich vegetation, where the population is among the densest in Sicily. At an altitude of about 2000 feet, cultivation seems to cease abruptly, so that a rather sharp line of demarcation can be drawn between this and the upper region, which presents a remarkable contrast; covering the great extent of something like two hundred square miles, almost without a house or an inhabitant. Some thin and scattered plantations of chestnut trees reach on the southeastern side to an altitude of 4 or 5000 feet, but this region is, as I say, uninhabited, and above this, all is barren, consisting of wastes of lava. There is at the foot of the final cone, a hut called Casa Inglese, used in summer by the few tourists to the summit, and deserted during the rest of the year, during a considerable part of which, it is usually, in fact, buried beneath the snow. This being some eight hours journey beyond food, fuel or water, can only be used for a few hours, except by a permanently organized occupation, such as is in fact to be undertaken with the resources of the local government, which proposes to make of it the Etnean Observatory. This point being quite out of the question, for me, as a residence, I was advised at Catania to make my stay at Nicolosi, the highest village on the mountain, and whose elevation is a little over 2000 feet. It seemed, however, that a higher altitude would be desirable, but the difficulty was to find a station where wood and water could be had with some kind of shelter. Fortunately there exists about three hours' journey above Nicolosi, a cistern containing excellent water, near which is a hut built of lava, known as "Casa del Bosco." It is scarcely the "house" its title denotes it to be, but it has walls, a roof, and even a kind of fire-place, while the chestnut plantation in the vicinity makes it possible to obtain fuel.

I had no hesitation in choosing this, then, and though the quarters were certainly not as comfortable as those I had left at Catania, I found them sufficient. The hut stands at an ele-

vation of about 4,200 feet, on the southeast slope of the mountain. It is in lat. 37° 38′ 55″·5 N. and long. 6^h 08^m $11^s·5$ east of Washington.*

After a preliminary visit, I ascended the mountain on Dec. 25th, 1878 (Christmas day), leaving Catania in the morning, and reaching the "Casa" after dark. I had no aid or assistant, but was accompanied by a native guide and by soldiers (Carabinieri) sent by the Prefect of Catania, all of whom remained with me. These soldiers were sent on the application of the Honorable Mr. Marsh, Minister of the United States at Rome, who kindly and effectually interested himself to procure me official introductions from the Italian ministry to the Prefect of Catania, and I was obliged in this as in other instances, by every attention which our own consular officers or the Sicilian authorities could render.

My instruments consisted of a telescope of $3\frac{1}{4}$ inches aperture, mounted equatorially (but without circles), and resting upon a tripod stand. It is the property of the United States Naval Observatory, and for its loan I am specially indebted to the kindness of Admiral John Rodgers, the Superintendent. With this was a spectroscope, belonging to the Allegheny Observatory, provided with a Rutherfurd speculum metal grating of 17,296 lines to the inch, and with collimating and observing telescopes of 1·1 inch aperture and 14 inches focal length. I had no chronometer, nor any means for observations of precision.

The observations were to be directed to the sole end of determining the character of vision, as tested at night by observations on stars and nebulæ, and by day upon the sun. I was furnished by the kindness of Mr. Burnham, of Chicago, with a list of test objects, which included, however, many very difficult with such an aperture, or indeed beyond its reach, as the list was made at my request, in expectation of the use of a larger instrument than the one actually employed. I confined myself chiefly to the examination of a small number of very familiar and mostly easy test objects, adopting the plan of limiting the aperture by graded diaphragms, until the smallest one was found through which the object could be steadily seen. The same objects can always be tried with the same apertures elsewhere, but not always with the same eye, and since eyes differ, it is important to say that my own possess no special sensitiveness. In former years, while engaged with others upon such delicate objects as the inner satellites of Saturn, or on double-star work, I have never been able to flatter myself that my vision in this respect was at all keener than the average. My eye, for instance, on clear nights, at ordinary ele-

* I am indebted for these determinations to the kindness of Professor C. H. F. Peters.

vations, does not recognize *steadily* more than six stars in the Pleiades, and sees a seventh and eighth by glimpses, and on an ordinary clear night at Allegheny, I cannot steadily see the companion of Polaris with less than two inches aperture.

I proceed to give some of the tests of light from observations made on the nights of December 28th, 31st, 1878, and January 1st, 4th, 10th, 13th, 1879. The aperture employed is $3\frac{1}{4}$ inches, where not otherwise stated.

Pleiades with naked eye, moon not set, *nine* stars steadily visible.

Companion of Polaris (position previously unknown), recognized with 1·6 in. aperture.

Companion of Rigel steadily seen with 1·6 in. aperture, not seen with 1·4 in.

β Leporis. Companion (mag. 11) seen with full aperture.

α Tauri. Companion (mag. 11·2) an easy object with full aperture.

December 31st. The nebula in Orion being about 40° high and moon half full, the 5th star in the trapezium was seen with full aperture.

ι Orionis. The 3d star (11th mag.) seen with $3\frac{1}{4}$ in. A little later, however, the definition being worse, could not discern the 11th mag. star preceding σ Orionis.

January 4th. 5th star in trapezium of Orion steadily seen, but could not be sure of 6th.

3d star of ι Orionis (11th mag.) seen with $3\frac{1}{4}$ in. in spite of moonlight.

January 10th, 11th mag. star preceding σ Orionis, also 11th mag. star of ι Orionis well seen in spite of moon and the tremor from wind.

The observations for stars included many others, which were less satisfactory, and I select from them this small list, with the remark that in the five nights which were all that presented themselves for this work, the wind was an almost constant obstacle to steady vision, while I was compelled to observe in the moonlight, and while from the construction of the tripod stand, I was generally obliged to omit objects at an altitude of much over 60°. Considering the distinctness with which objects of 11 to 11·2 magnitude were seen under these circumstances, I think we shall be justified in stating that the limit, for an ordinary eye and the aperture employed (3·25 in.), at this altitude on Etna cannot be far from the 11·5 magnitude of the Bedford catalogue, or the 10·2 magnitude of Struve's scale. I have employed the scale of the Bedford catalogue partly because Mr. Webb, in his very excellent little manual, makes the remark that to an ordinary eye and telescope, the 11th magnitude (of this catalogue) is the limit of vision to 3·7 in. aperture (in England), and because in the absence of more exact data,

we may be interested in observing what this will give as the relative transparency of the respective atmospheres. For this purpose, let the absolute light of the 11th magnitude star be unity and as that of the 10th is approximately $2\frac{1}{2}$ times, and that of the 12th $\frac{2}{5}$ of this; that of the 11·2 (the smallest certainly seen), is represented by the number whose logarithm is $\left(1-\frac{\log. 2{\cdot}5}{5}\right)=\cdot 83$ and $\left(\frac{3{\cdot}25}{3{\cdot}7}\right)^2 \cdot 83=\cdot 64$. This would appear to show that stars of about $\frac{2}{3}$ the brightness of those visible in England under like telescopic power can be seen on Etna at the altitude of Casa del Bosco.

We may obtain means for comparing the transparency of the atmosphere at any station on successive evenings, or at any number of different stations, by observing with the naked eye, two stars, one high and one low in altitude, which appear to have the same brightness at a given time; for the light of the lower one must have been diminished by a calculably greater amount than that of the upper, and this difference will furnish a measure of the absorptive power of the atmosphere.

Thus let a be the coefficient of transmission of our atmosphere, so that a star in the zenith whose absolute light is L, appears with a light La, to an eye viewing it through the intervening vertical column of atmosphere (=1). A star L_1 at the zenith distance z, whose light is more absorbed by the longer column of air (=sec z_1) will appear of the brightness $L_1 a^{\sec z_1}$ that of a lower star L_2 of the brightness $L_2 a^{\sec z_2}$ and if these two appear equally bright, $L_1 a^{\sec z_1}=L_2 a^{\sec z_2}$, whence

$$\log a=\frac{\text{Log } L_1-\text{Log } L_2}{\sec z_2-\sec z_1}.$$

(We neglect the effects of refraction and of selective absorption). We need the relative lights only, and these we obtain by assuming as before that the light of each magnitude is $2\frac{1}{2}$ times that of the next below, an assumption which is sufficiently close to fact for our present purpose.

The following stars were thus compared. The times of comparison were taken from a common watch, and from these the zenith distances are found by subsequent computation, the magnitude being here taken from Heiss and Argelander reduced to Peirce's scale.

If any conclusion may be drawn from so very limited a number of comparisons, we may infer then, that at this station about nine-tenths of the light of a zenith star reaches us, and, that only one-tenth is absorbed by our atmosphere, but it is probably that this absorption is in reality somewhat greater.

Station, Catania.

Stars Matched.	Date.	ζ	Mag.	Log L.	sec ζ_2 / sec ζ_1.	Log L_1 / Log L_2.	log *a.*	*a.*
γ Cephei	Dec. 23d, 1878	45° 12′	3·55	−1·42				
ζ Urs. Maj.	8h 53m M. T.	84 52	2·1	−0·84	+9·76	−0·58	−0·059	0·87
δ Cassiop.	Dec. 23d, 1878	28 49	3·0	−1·20				
η Draconis	9h 06m M. T.	79 25	2·8	−1·12	+4·30	−0·08	−0·019	0·96
γ Cephei	Dec. 23d, 1878	52 40	3·55	−1·42				
η Urs. Maj.	11h 08m M. T.	79 45	2·07	−0·83	+3·97	−0·59	−0·149	0·71
β Cassiop.	Dec. 24th, 1878	21 27	2·35	−0·94				
β Urs. Maj.	6h 17m M. T.	83 27	2·1	−0·84	+7·69	−0·10	−0·013	0·97
							Mean	0·88

Station, Casa del Bosco.

Stars Matched.	Date.	ζ	Mag.	Log L.	sec ζ_2 / sec ζ_1.	Log L_1 / Log L_2.	log *a.*	*a.*
γ Geminorum	Jan. 4th, 1879	38° 46′	2·6	−1·04				
γ Leonis	9h 07m M. T.	79 52	2·1	−0·84	+4·40	−0·20	−0·046	0·90
Mean of β & δ Aurigae	Jan. 4th, 1879	(12°)	(3·15)	−1·26				
β Leonis	10h 50m M. T.	80° 10′	2·1	−0·84	+4·84	−0·42	−0·087	0·82
ζ Tauri	Jan. 4th, 1879	17 54	3·55	−1·42				
α Can. Ven.	11h 05m M. T.	75 30	3·07	−1·23	+2·94	−0·19	−0·065	0·86
ϵ Persei	Jan. 10th, 1879	19 10	3·25	−1·34				
β Can. Min.	6h 53m M. T.	74 44	3·15	−1·26	+2·74	−0·08	−0·029	0·94
γ Cassiop.	Jan. 10th, 1879	26 31	2·1	−0·84				
β Urs. Maj.	7h 00m M. T.	75 57	2·1	−0·84	+3·00	±0·00	0·000	1·00
γ Persei	Jan. 13th, 1879	15 22	3·07	−1·23				
γ Urs. Min.	7h 28m M. T.	69 01	2·9	−1·16	+1·76	−0·07	−0·040	0·91
							Mean	0·90

These general conclusions as to the clearness of the atmosphere must not lead us to think that it is uniformly clear, or that the definition is uniformly good at such a mountain station, or that we have not to exercise patience and wait for opportunity as well there as below. Thus I find such entries as these frequently recurring:

"Jan'y 1st, '79.—Definition very ordinary, with haziness of sky. Companion of Rigel not conspicuous with full aperture."

Jan'y 13th.—The sky seems clear, yet I cannot see the companion of 84 Ceti (9–10 mag.) with full aperture. The night is like one at home, with no good view of faint objects, though with fair definition," etc.

Reviewing my experience, I should say that the gain on Etna over a lower station, as tried by the tests of a double-star observer, was more in clearness of the atmosphere than in that freedom from tremor which accompanies good definition. The latter was indeed upon the whole better than below, but not conspicuously so.

I had occasion in August, 1878, to notice the remarkable extent and brightness of the milky way, as seen from the Colorado plains, and still more from Pike's Peak. The appearance of a nebula is perhaps indeed the best test to an experienced eye, of the quality of transparency in any atmosphere, and I was desirous of making a sketch of the nebula of Orion, as a useful measure of this transparency at my station. It was not easy to do this, however, as in most of the few clear hours which presented themselves, I was troubled by moonlight. The whole time I was thus able to give the sketch was hardly equal to more than two or perhaps three consecutive hours, although something was done at it on every opportunity, when other work permitted. With undivided attention I believe many more details might have been gathered.*

At the present time, the study of the sun is of increasing importance, and the obstacles to clear telescopic vision in our lower atmosphere are found to be of more consequence, relatively to it, than to nocturnal observations. This arises in part from the greater disturbance of the air by the direct solar heat during the day, than in the night, when it is withdrawn; but this is not the only cause. In observations of precision, we generally seek before everything an optically tranquil atmosphere, and it is a fact familiar to every observer, that the best nights for all accurate measurements of position, are very commonly not the clearest, and that at night sharp definition is, almost as a rule, associated with more or less imperfect transparency; the latter being in itself of course a loss, but bringing an over-compensation in the steadiness of vision which accompanies it. This is so distinctly the case, that even minute points of light are then often best seen, as in the well-known instance of the discovery of the 8th satellite of Saturn by Bond, on a night when stars below the 4th magnitude were invisible to the naked eye.

Now in solar work we have to distinguish two classes of phenomena,—(1) those of the photosphere, seen directly by the telescope or recorded by photography; and (2) those pursued by the spectroscope, chiefly upon the chromosphere. For the first class, in general the condition of successful observation is an optical tranquillity of atmosphere rather than transparency.

* The drawings made are not reproduced here, but the originals are at the service of any one desiring to institute a comparison under like conditions.—S. P. L.

For all eye-studies of the photosphere, transparency is of so little value, that I have uniformly found direct telescopic study at Allegheny to be most successfully pursued on hazy days; the very finest definition I have ever obtained of the minute features of the photosphere and spots, being at times when the sun could be viewed with little danger to the naked eye, while even in solar photography it is found best to take advantage of the optical tranquillity of the atmosphere, just after the rising of the sun, in spite of the great loss of light from atmospheric absorption at that low altitude.

For the second class of observations, in which we may include, together with spectroscopic studies, many of those upon the sun's radiant heat, the conditions of success are notably different. Very faint uniform haze in the air, such as is quite consistent with the common impression of a bright sunny day, and passes unnoticed to the ordinary eye, puts an absolute stop to the study of the more delicate chromospheric phenomena. For these, a sky which remains of a deep blue even in the neighborhood of the sun (and which is not frequent with us in the Eastern United States), is welcomed even at the cost of poor definition in other respects, although the latter is here also very desirable. It is rarely, indeed, with us that the two conditions are united.

For tests of telescopic definition upon the surface of the photosphere, an experienced eye needs nothing more than the appearance of the cloud-forms there; for translucency of the atmosphere, the appearance of the chromospheric forms; and for the union of both requisites, the visibility of those chromospheric lines which, being due to vapors lying close to the solar limb, are hidden by the least agitation of the image. For the latter the lines *b*, and 1474 Kirchhoff were chosen, partly because I had understood from Professor Resphigi that their reversal formed severe tests of atmospheric definition, as tried by the conditions found at the Observatory of the Capitol (Rome), and also because Professor Tacchini mentions them as with difficulty seen by four inches aperture at Palermo.

I shall best give an idea of what may be expected on a mountain site, by direct extracts from my journal.

"December 28th, 1878, 10 A. M. The air perfectly tranquil to the naked eye, and a calm so absolute that the sound of voices in conversation is heard at a distance of half a mile.

Looked at sun with an aperture of one inch and lowest power. Definition *very* bad. 11.30 A. M. The sky is nearly as clear as I have ever seen it in Colorado or Egypt—not quite. Carrying the naked eye toward the sun, which is just shaded by a screen, there are very slight indications of a milkiness in the blue as the edge is approached,* but there is not that blackness, which I have

* This extremely simple test of transparency is the best I know.

observed in using the same test on Pike's Peak, or from the summit of the Pyramid of Gizeh. The transparency of the air is nevertheless such as is very rarely seen in the Eastern United States; but all this while, the *definition* continues very bad—almost as bad as I ever saw it anywhere.

December 29th, 1878. Morning warm and calm with light cirrus clouds. Examined sun with 2d power (70). Definition only ordinary, yet caught glimpses of "rice-grain" structure, such as could not have been seen at Allegheny under like definition (i. e. the extreme transparency which would almost never be found associated with even ordinary definition at home here told in favor).

December 31st, 1878. The sky of as transparent a blue as I have seen, and optically tranquil. The so-called "rice-grain" structure of the solar surface is beautifully defined with the highest telescopic power (212), and this is the best evidence of the possibilities of vision here, as I have *never* before seen such definition upon the sun, anywhere, and least of all under a blue sky. With the spectroscope, using the small Rutherfurd grating, work is difficult, owing to the absence of clockwork and the presence of wind. Yet under these disadvantages, D_3 can be used for viewing the forms of two adjacent protuberances, nearly as well as C, 1474 Kirchhoff is reversed, occasionally shining out nearly as bright as the "Helium" line, while b_1 is repeatedly seen bright also.

January 1st, 1879. No good definition anywhere. Much of day passed in fruitless attempts to get results from spectroscope.

January 2d, 1879. Sky milky blue near horizon, deep blue above, but not so deep as I have seen it on one or two exceptional occasions at Allegheny. I much regret not having a cyanometer but judge that this, an ordinary blue here, is deeper and purer than any but the very best, of the skies of the Eastern United States.

January 3d, 1879. Calm and warm, with light haze rendering work with spectroscope on chromosphere fruitless. D_3 only caught by glimpses.

January 4th, 1879. Sky deep blue but with occasional cirrus clouds about sun. Wind constant and day passed in waiting fruitlessly for a minute of steady vision.

January 5th, 1879. A violent wind, but sky clear, round sun. Whirlwinds and dust make it difficult to do anything, but a drawing of the E lines is made* 1474 K is doubled, and eight lines discerned between D_1 and D_2 (high sun).

I remained upon my Etnean station until the 14th of January, at which time the snow line had descended to some distance below me, and the weather became so bad that there was no prospect of adding materially to the results already obtained.

During my brief stay in Europe I had the pleasure of meeting several distinguished continental observers, and learned

*Not reduced here.

from them as far as I could, their opinions as to the conditions of observation at their respective positions. I found during a few days' stay in Egypt, a sky which appeared to give almost unequalled definition. I carried no instruments with me, but by the kindness of General Stone, of the Khedive's staff, had the loan of a small telescope, which I used on several nights, from the roof of my hotel in Cairo. Judging by this (if the nights were fairly typical, as they seemed to be), the winter climate of Egypt must be almost unequalled for astronomical purposes, the transparency and definition being alike admirable, and the freedom from tremor such that the discs of the stars I examined, seemed fixed in the center of interference rings, as sharp and motionless as engraved lines. The days were uniformly fine, but a slight haziness appeared, I thought, in the lower atmosphere, due, perhaps, to dust; which was surmounted by a moderate elevation.

From the top of the Great Pyramid at noon, I particularly noticed that the sky remained of a deep blue without a trace of "milkiness," while the eye was carried up almost to the very disc of the sun. This was equal to anything of the kind I have seen in the Rocky Mountains, but this was the only time when I found conditions of the kind as good here as I have seen them in our own western territory. I found only on this occasion, an absolutely *perfect* sky for the purposes of the student of chromospheric phenomena; but all the days were good in my brief stay, and I particularly noticed at other times the resemblance of the Egyptian atmosphere to that of our Colorado plains, as shown by the extreme definiteness of the desert horizon, which appears as a hard line, with a sky as blue at the very verge of vision as that we ordinarily see at the zenith.

The climate of lower Egypt, like that of our elevated western plains, is exceptionally dry, and I should have had, myself, little hesitation in stating that for most solar observations at least, the most promising conditions were found associated with such a dryness of atmosphere. I ought to state, however, that I found the opinion of M. Janssen (an eminently competent judge in such matters), to be that the best conditions exist when there is a great humidity in the atmosphere, *if without haze.* His experience in the Himalayas appears to confirm the impression I have gathered from all my own experience, that the mere fact of a high elevation by no means ensures good vision, though, other things being equal, the chances are better at a considerable altitude. Thus as I learned from him he found in 1869, both the definition and transparency at Simla (altitude 7,000 feet), generally worse than at Guntoor, near the sea level, while at the Neilgherry's, at an altitude of 6 or 7,000 feet, the winter vision was admirable, and this commonly was associated with a heavy fall of dew.

High elevations have undoubtedly the advantage of diminishing the atmospheric absorption of the more refrangible rays, an absorption so important that it probably cuts off from us the larger portion of the ultra-violet spectrum. M. Cornu, whose work on this portion is so well known, informed me that he found himself able to add about 1 c.m. (on the scale of his map) to this ultra-violet end, for each 500 m. of altitude, and that it was his intention in order to extend his work further, to make the Furca pass in the Alps his observing station during the present year; a testimony of importance to the gain in this direction to be expected from mountain observatories.

It appears from all that has preceded, that the balance of advantages is most likely to be found in a dry atmosphere, and certainly at a great elevation. The gain for observations of precision will be, though positive, not in itself probably such as to justify (unless for the work of the double-star observer), the difficulty and expense of such a site; but for the study of the nebulæ and stellar photometry the gain is very essential indeed, while for almost every problem in solar physics we may say without reserve that for rapid progress, such observatories have now become not merely desirable but indispensable.

The summit of a very lofty mountain is, however, even apart from any consideration of its inaccessibility, not a desirable station. At an altitude of 10 or 11,000 feet we may still enjoy all the conditions of health which fit us for labor, but if we ascend considerably beyond this, we find unfavorable conditions increasing very fast. If I may be allowed to quote from my own experience of a stay of ten days upon Pike's Peak, at an altitude of between 14 and 15,000 feet, and from what I learned from others, I should say that at this altitude the attenuated atmosphere makes a long stay impossible for some, while even for the healthiest, the conditions of life begin to be such as to render continuous hard work scarcely possible. At the same time, the mountain condenses about itself continuous clouds, so that, except during a brief period in the autumn, the opportunities for observation are far rarer than on the plains.

A dry climate and a table land at an elevation of something like 10,000 feet, sheltered on the side of the prevalent winds by a mountain range which precipitates their moisture in clouds that rarely advance beyond the observer's horizon, appear to be the most promising conditions in our present knowledge.

Upon the whole, then, though the ideal station, where atmospheric tremor does not exist, and the observer pursues his studies in an ever-transparent sky, is not to be found on any part of the earth's surface yet examined, we find within our own territory in the dry and elevated table lands of Col-

orado or New Mexico, every condition which experience points out as favorable. We shall find in the same territory contiguous stations under not dissimilar circumstances, where these favorable conditions do not exist; and, where so much is dependent upon a judicious choice, the preceding observations, I hope, may in spite of their incompleteness, furnish useful material for a more exact qualitative comparison, than has heretofore been practicable.

ART. IV.—*On the Antiquity of Certain Subordinate Types of Fresh-water and Land Mollusca;* by C. A. WHITE, Paleontologist to the U. S. National Museum.

AMONG existing fresh-water and land Mollusca there are certain comprehensive genera, which may be divided into a greater or less number of more or less distinctly definable groups, that are respectively recognizable by certain common characteristics, less conspicuous than those which separate the larger genera from each other. These minor groups have been treated as genera, sub-genera, or as still less important sections, by the various authors who have discussed them, according to the individual estimate that has been placed upon the relative value of the characters by which they are recognized. It is my present purpose, not to discuss the value of these distinctions as means of zoological classification, but to show that a considerable number, not only of the larger genera of living North American fresh-water and land Mollusca, but also a large proportion of the minor or subordinate types which those genera respectively embrace, had their origin as such, at least as early as the closing epochs of the Cretaceous, or the immediately following epochs of the Eocene Tertiary Period.

The fossil collections upon which these observations are based, and which alone are referred to in the following remarks, are those which have been obtained by the different U. S. Government Surveys in the western portion of our national domain. The strata which have furnished these fossils are, in the ascending order, those of the Fox Hills, Laramie, Wahsatch, Green River and Bridger groups. The first named of these groups is unquestionably Cretaceous, and the three last are as unquestionably Eocene Tertiary. The second I regard as representing a transitional epoch, but some geologists assign it to the Cretaceous period because of the presence of dinosaurian remains in its strata. Others refer it to the Tertiary, because of the characteristics of its floral remains. It is sufficient for my present purpose to say that the molluscan types here discussed are found in strata which range from the Cretaceous to the close of the Eocene, inclusive.

The comprehensive genera that embrace the minor types which are here more especially discussed or referred to are *Limnæa*, *Planorbis*, *Physa*, *Helix*, *Pupa*, *Succinea* and *Unio*. The minor types that may be mentioned as having representatives among the fossil collections already referred to are especially noticeable among the pulmonate Gasteropoda and the Unionidæ. The principal examples of the former are indicated by the following list of the names by which the types are known and which have been applied to them by different authors in either a generic or sub-generic sense. These examples by no means represent even approximately the full molluscan fanuæ of which they form a part, but they are selected for the special purpose already indicated.

LIMNÆINÆ.
1. *Acella* Haldeman.
2. *Leptolimnea* Swainson.
3. *Limnophysa* Fitzinger.

PLANORBINÆ.
4. *Planorbis* (typical), Guettard.
5. *Bathyomphalus* Agassiz.
6. *Gyraulus* Agassiz.

PHYSINÆ.
7. *Physa* (typical) Draparnaud.
8. *Bulinus* Adanson.

HELICINÆ.
9. *Aglaia* Albers.
10. *Arianta* Leach.
11. *Patula* Haldeman.
12. *Strobila* Morse.
13. *Triodopsis* Rafinesque.

PUPINÆ.
14. *Lucocheila* Alh. & Mart.
15. *Pupilla* Leach.
16. *Holospira?* Albers.*

SUCCINÆ.
17. *Brachyspira* Pfeiffer.

It should be mentioned that these subordinate types were originally recognized among, and their names applied wholly to, living forms. The discovery of fossil forms of those types is a gratifying confirmation of their genuineness (time being the crucial test of permanency), and proof of the sagacity of their authors.

Acella is represented by *A. Haldemani* White† from the Laramie strata of Bear River Valley, Wyoming. With the probable exception of an undescribed form in the Green River strata of Wyoming, no other fossil species of that type is yet known; but the *Limnæa* (*Pleurolimnæa*) *tenuicostata* of Meek and Hayden, from the Laramie strata of Montana, is a closely allied form. *Limnæa* (*Leptolimnea?*) *minuscula* White, from the Green River strata of Wyoming, appears to possess the characteristics of *Leptolimnea* Swainson. The earliest known species of *Limnophysa* is *L. nitidula* Meek, which is associated with *Acella Haldemani*, just mentioned. Two other species from the Green River group of Wyoming are referred to that type, namely, *L. vetusta* and *L. similis* Meek.

* *Holospira* is placed here under the *Pupinæ* only conventionally.

† The species herein mentioned are described and in part figured, in the following publications: Annual Reports U. S. Geol. Sur. Terr.; vol. ix, (4to Ser.) of the same; Bulletin of the same; Powell's Rep. Geol. Uinta Mts.; U. S. Expl. and Sur. west or the 100th Merid., vol. iv; U. S. Geol. Sur. 40th Parallel, vol. iv; Simpson's Rep. Great Basin Utah; and Proc. U. S. National Museum, vol. iii. (The latter now in press).

Planorbis proper is represented by *P. æqualis* White, in the Green River strata of Wyoming. *Bathyomphalus* has two representatives, namely, *P.* (*B.*) *Kanabensis* White, and *P.* (*B.*) *planoconvexus* Meek & Hayden; both in the Laramie Group. The former comes from Southern Utah, and the latter from Montana. *Gyraulus* appears to have several representatives in both the Laramie and Green River strata; but *G. militaris* White, from strata probably of the Laramie period, is the only one yet published.

A considerable number of species of the Physinæ are known in the Laramie, Wahsatch and Green River groups, and the sub-family was well established before the first named period. It is an interesting fact, in confirmation of the latter statement, that a typical species of *Physa*, *P. Carletoni* Meek, has been found in estuary strata at Coalville, Utah, which rest upon marine Cretaceous strata, and have more than 1,000 feet of similar marine Cretaceous strata resting upon them. This is the earliest *Physa* known in American strata. *Physa pleromatis* White, is a widely distributed species in the Wahsatch group of Wyoming, Colorado and Utah, but true *Physa* is not common in the Laramie group, although that genus prevailed both before and after. In the last named group *Bulinus* is somewhat common; *B. atavus* White, and *B. subelongatus* Meek & Hayden, being published examples.

The *Helicinæ* appear to have been almost as diversely differentiated during the Laramie, Wahsatch and Green River epochs as they are at the present day; no less than five of the subordinate types embraced in that sub-family having been more or less satisfactorily recognized among the molluscan faunæ of those epochs. *Aglaia* is represented by *Helix peripheria* White, in the Green River group of Utah; and *Arianta* by *H. reparia* White in the same group of Southern Wyoming. *Helix Kanabensis* White, seems to possess the distinguishing characteristics of *Strobila*. It occurs in the upper part of the Laramie group of Southern Utah. *Patula* is represented by *Helix sepulta* White, in the coal-bearing strata of Evanston, Wyoming, which belong either to the upper part of the Laramie group, or the base of the Wahsatch, probably the former; and apparently also by an undescribed species in the Green River group of Wyoming. *Triodopsis* is represented by *Helix Evanstonensis* White, which is associated with *H. sepulta*, just mentioned.

The *Pupinæ* have been recognized only in the Green River and Bridger groups; four species only having yet been discovered. The true character of the aperture has been ascertained only in one of these, and they are therefore assigned to the types mentioned, with some doubt. Their diverse forms, how-

ever, indicate that a wide differentiation had taken place in the *Pupinæ* at that early time. *Pupa arenula* and *P. atavuncula* White, discovered in the Green River strata of Wyoming, are referred provisionally to *Pupilla*, and an associated species *Pupa incolata* White, to *Lucocheila*. Mr. Meek referred his *Pupa Leidyi* doubtfully to *Holospira*. It is from the Bridger strata of Wyoming.

Only one species of the *Succininæ* has yet been discovered in any of the strata here considered, namely, *Succinea papillispira* of the Green River strata of Wyoming. This is plainly referable to *Brachyspira*.

The *Unionidæ* of the fossil molluscan faunæ, herein discussed, are found to have become differentiated to a remarkable extent, especially during the Laramie epoch. An exceedingly interesting and suggestive fact in connection with this differentiation is that the subordinate types are largely indentical in character with some of those which are now living in the waters of the Mississippi River system, and which are recognized by malacologists as distinctively North American types. Illustrative of this relation of the fossil to the recent forms, the following parallel lists are presented, those of the left-hand column being a part of the fossil species now known in the Laramie strata of Wyoming and Utah; and those of the right-hand column being the living species of the Mississippi River system which are selected as their respective type-congeners.

Unio propheticus White.	*U. clavus* Lamarck.
U. proavitus W.	*U. ridibundus* Say.
U. gonionotus W.	*U. multiplicatus* Lea.
U. holmesianus W.	*U. apiculatus* Say.
U. Couesi W.	*U. complanatus* Solander.
U. Endlichi W.	*U. gibbus* Barnes.
U. brachyopisthus W.	*U. circulus* Lea.

Still other examples might be given of close resemblances between fossil and recent forms of *Unio*, but these suffice to suggest, in a very forcible manner, that the *Unione* fauna of the Mississippi River system is genetically related to that of the Laramie period. It is true that in the Laramie fauna there are certain minor types of *Unio* which are not so closely like any living forms as those are which have been cited, and that close congeners of certain living types have not been discovered among the fossil forms; but these facts do not necessarily affect the legitimacy of the conclusion that the living has genetically descended from the fossil fauna. A like conclusion is also reached with reference to the pulmonate gasteropods which have already been discussed; but in view of the magnitude of the physical changes which have taken place since the close of even the latest epoch here considered, the survival of the types of the branchiferous Mollusca, and their transference from lacustrine to fluvatile waters, is a most remarkable circumstance.

Reviewing the collections which represent the fossil faunæ herein discussed, so many familiar forms are seen that it is difficult to realize the fact that a large proportion of them, including those especially which have been mentioned by name in this article, were living contemporaneously with the last of the Dinosaurs. Yet such is the fact, and the shells of the former are often found commingled with the bones of the latter. What were the successive steps in the history of the transmission of these types from that remote time to the present we are unfortunately without the means of knowing with certainty, because of the remarkable paucity of molluscan remains in all the deposits of the great interior region later than the Eocene. All the molluscan remains, which have been found in these later deposits, belong to familiar living types, although of extinct species.

That the palustral and land pulmonates might have been, and perhaps were, preserved under immediate conditions differing from those which insured the survival of the Unionidæ is evident; but certain facts point to the conclusion that the peculiar "North American" types of Uniones which prevailed in the Laramie epoch were not transmitted through the Eocene, Miocene and Pliocene epochs as denizens of the fresh-water lakes which succeeded the brackish water of the Laramie sea, and each other, in their occupancy of a great part of the interior region of North America, up to at least near the close of the Pliocene epoch. The Eocene fresh-water deposits contain a considerable number of species of *Unio*, it is true, but they are all, so far as known, of a smooth surface and oval form, and constitute a type which, although common among living Uniones, is exceedingly rare if not entirely wanting in the Laramie group. The conclusion therefore seems necessary that those peculiar and varied forms of *Unio* which have been mentioned in the preceding list, with their faunal molluscan associates, escaped from the Laramie lacustrine waters before the close of that epoch, into those fluviatile waters which formed the outlet to the lacustrine, and which became a part of the Mississippi drainage system, as the elevation of the continent progressed.*

The magnitude of the physical changes which have taken place upon the North American continent since the epochs in which the Mollusca lived, which are discussed in this article, has already been referred to. These changes were no less than the gradual desiccation of the region formerly occupied by great inland lakes, which for magnitude have now no equals upon the earth; the elevation of the whole Rocky Mountain system, and the establishment of the present great interior river systems. Through all these changes these molluscan

* This subject is discussed at some length in Bull. U. S. Geol. Sur. Terr., vol. iii, p. 615.

types have come down to us in unbroken lines some of which, to speak figuratively, were of remarkable tenuity. It is true there has been a dropping out of some of the earlier associated types and an introduction of new ones as the epochs passed, but the lines of descent of the numerous types which have reached us unbroken, seem to be almost parallel, so little have they changed with the lapse of time. So slightly divergent are these lines, considered as lines of differentiation, that if we bound them all by two imaginary straight lines, we shall have an evolutional parallax that would carry back the origin of these types to a period inconceivably remote. We must therefore conclude that their origin was, at least in some degree, saltatory; but the real conditions under which they originated must probably always remain obscure. I have, however, elsewhere* suggested, that the differentiation of the Unionidæ took place under the influence of salt in the water in which they lived; but it is plain that this explanation will not apply to the case of the palustral and land mollusca.

ART. V.—*Description of a new Position Micrometer;* by LEONARD WALDO.

THERE has lately been added to the instrumental equipment of the Winchester Observatory of Yale College, a position micrometer, of a new design, though the separate ideas embodied in it I have gathered from other observers' experience as well as my own.†

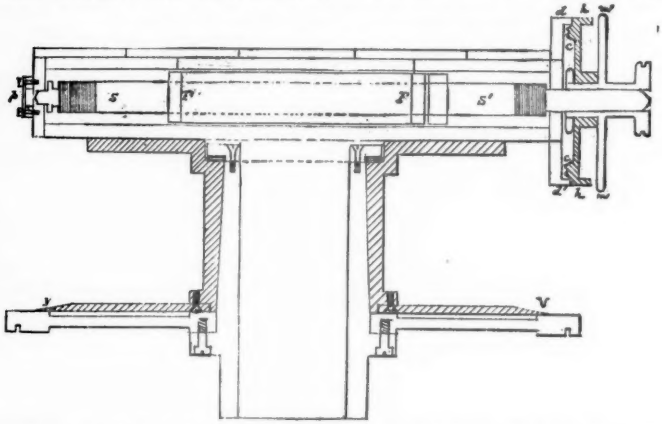
There are two sources of trouble in the filar micrometer as ordinarily constructed. The unguent used, if it has enough body to it to be really serviceable, becomes waxy and stiff in the cold of winter's nights. As a result, the screw, whether bearing at its point or at a shoulder, only gradually comes to a fixed position as it is turned. The spring which is used to take up the dead motion of the screw varies its pressure from one-fourth to three-fourths or more of its whole amount as the micrometer frame is moved from one end of its box to the other end.

In the micrometer about to be described, both of these difficulties seem to be overcome. The screw bears, without any unguent, against an agate plane, and the pressure of both the springs is practically constant in any position of the micrometer frame, which is liable to occur in actual use. In the sketches, *s s'* represents the screw which is 19 cm. long, and 8 mm. in diam-

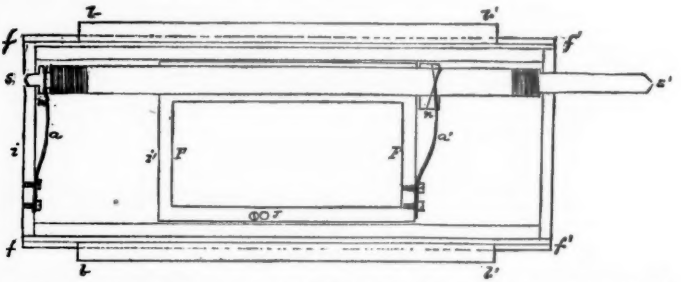
* Bull. U. S. Geol. Surv. Terr., vol. iii, p. 623.

† I am principally indebted to Professors Lyman and Harkness, and the Messrs. Repsold.

eter at the part where the thread is cut. The thread is cut for a length of 14·3 cm. and is evidently meant to be 80 revolutions to the inch. The frame FF which carries the movable webs, is cut its whole length as a matrix through which the screw works; and in order that this frame shall have no dead



motion, there is a small matrix, n, about 1 mm. distant from it, which is prevented from rotating as the screw is turned, and against which the spring a' presses. This spring having one end screwed to the frame, and the other end pressing against the small matrix, tends to push them together, and thus the dead motion of both is destroyed.



The end of the screw at S is held firmly against an adjustable agate plane at p, by means of a second spring a which acts against a collar m. This spring needs to be quite stiff, for in one position of the micrometer box the weight of the screw and frame must be supported by it.

An adjustable agate jewel at J is the only point upon which the frame rests upon its box; and as pointed out by Lord

Lindsay* this form of mounting the frame is most likely to secure permanency in the errors of the screw, so that when once determined they may be assumed to remain constant for long intervals.

The micrometer frame *fff'f'* may be moved in the grooved bearings *b b b' b'* by a screw, which is not shown in the sketch, opposing the micrometer.

The eye pieces also have a parallel motion by rack and pinion. The screw head may be read by two pointers *d* and *d'*, and the whole revolutions are registered by a toothed wheel which gears into the thread cut on the micrometer head and shown at *c c*. The milled head, *m m*, is larger than the disc carrying the graduations. The bright web illumination is effected in a manner similar to that adopted by Alvan Clark & Sons. There is an aperture at *i* protected by a glass cover and a similar one at *i'* which allows the light from a lamp to impinge on the webs in the frame.

The position circle reads by two verniers to 30″ and is provided with a coarser graduation to single degrees. The workmanship throughout is in the highest degree creditable to its makers, Messrs. Fauth & Co. of Washington, D. C.

The following observations on the revolutions of the screw between 22·50 rev. and 27·50 rev. were made with the microscope comparator I have previously described.†

I.	II.	III.	IV.
Rev.	d.	d.	mm.
22·500			
	5·07	+0·02	+0·00031
22·750			
	4·95	−0·10	−0·00157
23·000			
	5·03	−0·02	−0·00031
·250			
	5·12	+0·07	+0·00110
·500			
	5·10	+0·05	+0·00079
23·750			
	5·00	−0·05	−0·00079
24·000			
	5·03	−0·02	−0·00031
·250			
	5·05	0·00	0·00000
·500			
	5·07	+0·02	+0·00031
24·750			
	5·08	+0·03	+0·00047
25·000			
	4·97	−0·08	−0·00126
·250			
	5·16	+0·11	+0·00173
·500			
	5·03	−0·02	+0·00031
25·750			
	5·00	−0·05	−0·00079
26·000			
	5·06	+0·01	+0·00016
·250			
	5·05	0·00	0·00000
·500			
	5·03	−0·02	−0·00031
27·750			
	5·10	+0·05	+0·00079
27·000			
	5·03	−0·02	−0·00031
·250			
	5·07	+0·02	+0·00031
27·500			

* Dun. Echt. Obs. Pub., vol. ii, p. 53.

† Proc. Am. Acad. Arts and Sci. Bost., vol. xiii, for 1877–78, p. 352.

Column I gives the readings of the position micrometer. Column II, which is the mean of three readings, is the value in terms of the microscope micrometer scale of the interval 0·250 rev. occurring between the two successive readings of the position micrometer. Column III is the deviation of these intervals from the mean in terms of the microscope micrometer. Column IV gives these deviations expressed in millimeters.

The small residuals in column IV would apparently indicate that there are no greater errors to be apprehended from this form than from the ordinary construction, and it seems to possess very marked advantages for use in all observations which are carried throughout the year, and where the micrometer will be used on the same objects under the diverse conditions of winter and summer. This would seem to be particularly desirable for researches upon the stellar parallaxes.

ART. VI.—*On Boltzman's Method for Determining the Velocity of an Electric Current;* by E. H. HALL.

IN the June number of this Journal is mentioned a note relative to the velocity of electricity, published by Prof. Boltzman in the *Kaiserliche Akademie der Wissenschaften in Wien*, Jan. 15th, 1880. In this note Prof. Boltzman points out a method by which, as he thinks, the absolute velocity of current electricity may be determined from the results furnished by the study of a phenomenon lately described in this Journal* under the title, "A New Action of the Magnet on Electric Currents." Quite recently there has appeared in the *Kais. Akad.*, etc., an account of experiments and calculations made by Albert v. Ettinghausen, whereby he deduces for the electrical current sent by "one or two Daniels' cells" through his strip of gold the velocity 1·2 mm. per second.

Unless I have misunderstood Prof. Boltzman's note, however, there is a fatal objection to the fundamental assumption which he makes. I will give very briefly his method of reasoning as I understand it.

We know, as Prof. Boltzman says, that a conductor bearing a current is acted upon by a force tending to move it in a direction at right angles to the direction of the magnetic force acting upon it. We know, moreover, from the new phenomenon that there is at the same time a difference of potential set up between points on opposite sides of the conductor, and that the electromotive force thus arising is in the same line as the above force acting upon the conductor.

Consider now any particle of electricity in the conductor.

* March, 1880, p. 200.

It is acted upon by the newly-discovered transverse force, tends to move accordingly, and tends to draw the conductor with it. Imagine enough particles of electricity crowded into the conductor, and we have the explanation of the familiar action between magnets and conductors bearing currents. Knowing, therefore, the strength of our magnetic field, the strength of the primary current and the consequent difference of potential on opposite sides of the conductor, we can calculate exactly the amount of electricity contained in unit length of the conductor, at any moment while the current is flowing. Knowing, moreover, the amount of electricity passing through the conductor in unit of time, which quantity is of course what we call the strength of the current, it is a perfectly simple matter to determine the velocity of the current.

This question meanwhile presents itself. If the very slight difference of potential existing between opposite sides of the conductor is sufficient, when acting upon the electricity contained within the conductor, to cause the strong action which everyone has observed between magnets and conductors bearing currents, why is there not an enormously greater force always acting upon the conductor in the direction of the primary electromotive force and primary current?

To get a more definite view of the matter, suppose we send through a strip of gold leaf a centimeter wide and of any length a current of strength ·05 (cm-grm-sec.), and place the strip in a magnetic field of strength 4000. A certain difference of potential would now be observed between points opposite each other on the edges of the strip. This difference of potential, E′, would in the case imagined be perhaps $\frac{1}{3000}$ the difference of potential, E, for two points a centimeter apart in the line of the main current. Now, the force acting upon a unit length of the conductor to move it across the lines of magnetic force would be $4{,}000 \times {\cdot}05 = 200$ dynes.

This force everybody knows to exist. Let us suppose for the moment, with Prof. Boltzman, that it is due to the difference of potential E′ acting upon the electricity in the conductor. But now we have the difference of potential E, 3,000 times as great as E′, acting upon the same electricity but acting in the direction of the current.

To be consistent, therefore, we must look for a force in this direction equal to $3{,}000 \times 200 = 600{,}000$ dynes, a force equal to the weight of about 600 grams, acting upon each unit length of the gold leaf strip. Thus in following out Prof. Boltzman's assumption to what seems to me its necessary consequences we are led to a manifest absurdity.

Another objection to the above assumption, and a serious one apparently, is found in a fact not known to Prof. Boltzman when his note was written.

The transverse electromotive force in iron is opposite in direction to that in gold. According to the theory proposed, therefore, an iron wire bearing a current should move across the lines of magnetic force in a direction contrary to that followed by wires of other materials, which it does not do.

In view of these difficulties, it seems hardly possible at present to accept Prof. Boltzman's method of calculating the velocity of electricity.

Anyone desiring to see Prof. Boltzman's note will find a translation of the same in the Philosophical Magazine of April, 1880, p. 308. A rather confusing inaccuracy in translation is, however, to be found about the middle of page 308 in the sentence, "Hence, if the force above denoted by *K itself* acts upon, etc." This should read, "Hence, if the force above denoted by *K* acts upon the movable electricity *itself* in the gold leaf, etc." The position of the pronoun is here a matter of considerable importance, as anyone will see who reads Prof. Boltzman's note with care.

ART. VII.—*Mineralogical Notices;* by CHARLES UPHAM SHEPARD, Emeritus Professor of Natural History in Amherst College.

1. *A peculiar mineral of the Scapolite family.*

THE substance here described was sent to me by that zealous mineralogist, Mr. John G. Miller, of East Templeton, Ottawa County, Canada. It occurs in the bluish gray saccharine limestone of Galway, Ontario County, Canada. It had been referred with a query to chiastolite, which it certainly resembles in several respects. It presents itself in distinct and rather large crystals, thickly disseminated through the gangue, crossing each other in various directions. Their form is that of a right square prism, with truncated lateral edges. Their terminations are imperfect, and when well defined even, are still rough and drusy. They exhibit no combinations with the prismatic planes. The usual habit of the crystals is distinctly quadrangular, though in the larger individuals they are octangular, having their sides about equally produced. Their length is many times their thickness; and they are uniformly straight and sharply defined. The largest have a diameter of an inch, the smallest are rarely below one-eighth of this size. They preserve the same diameter throughout their length, with the exception of a single example, where one of the larger size, shows a tendency to a regular acumination. The length of this crystal is $3\frac{1}{2}$ inches, its diameter at the larger extremity

being half an inch, and at the smaller, but one-third. All the crystals have much evenness of surface and considerable smoothness, notwithstanding a slight degree of pitting or indentation, which almost requires a microscope for observation. They are without striation. The color is black, with a slight intermixture of gray and blue. In a few instances an area of cyanite-blue occupies a face of the larger crystals, but only to a slight depth from the surface. This part of the crystal is semi-transparent; while for the rest, the entire mineral is dark ash gray to bluish black, and only translucent on the edges. The vertical cleavages, parallel with the primary prism, are distinct, though effected with difficulty. They take place parallel with the narrower planes in the quadrangular prisms. Only traces of a transverse cleavage exist. A marked peculiarity of the larger crystals is the regular interlamination of thin films of white calcite, parallel with the eight sides of the prism. These layers, to the number of two or three, are equi-distant, thus imparting to the fractured ends of the crystals a checkered aspect, strongly suggesting the structure of chiastolite.* Luster, resinous to vitreous. Hardness = 7· . . . 7·5. Specific gravity, 2·608.

A very striking peculiarity of the mineral is the extremely fetid odor occasioned by its fracture; nor does this cease to be emitted until the fragments are reduced to an impalpable powder. The color of the powder is a bluish ash gray. It cannot be regarded as a hydrated mineral, as its content of water does not exceed 1·6 p. c. By exposure, however, to full ignition in a shallow platinum dish for several hours, it loses 4·6 p. c., this loss proceeding from the presence of organic matter, graphite, and carbonic acid from the decomposition of carbonate of lime. The powder still partially retains its grayish tint after long ignition; and it is only before the blowpipe that the portion most strongly heated loses its color. The thinnest part then undergoes fusion, attended by a feeble ebullition, into a colorless transparent glass.

Owing to the variable presence of graphite, calcite and quartz, the chemical examination is attended with uncertainty. The Si varied from 48·65 to 51·30; the Al from 13·45 to 19·62; the Ca from 17·43 to 21·6, and the Ti from 4·35 to 5·21. In a single trial, Na 4·35, and K 1·109, Mg 0·468 were obtained. The powder is very feebly acted upon by the strong acids.

From the foregoing it would appear that the mineral differs chemically from normal scapolite, and especially from the

* Prof. E. S. Dana has kindly made a section of one of the crystals, and examined it in polarized light. He finds "the black color to be due to foreign matter, present in the form of minute grains that may be metallic, making up no small part of the whole," and is of the opinion that "its analysis is not a guide to the real composition of the mineral."

vitreous couseranite of Saleix (Pyrenees) analyzed by Pisani; though it must be kept in mind that the example analyzed by him had been so much altered as to have its hardness reduced to 3. I am therefore led to regard the Galway crystals as the original, unaltered mineral, from which couseranite and dipyre have originated through hydration,* in the same manner as scapolite has given rise to wilsonite, huntite, algerite and terénite. Should it prove a new species, I propose to call it *Ontariolite.*

2. *Cassiterite at Coosa, Ala.*

Among the smaller fragments and grains of tantalite from this interesting locality, I find numerous crystals of cassiterite, the largest of which do not exceed the size of a pea. Some of them are well-formed octahedral crystals, showing, however, narrow faces of the primary prism, between the pyramids. When heated before the blowpipe on charcoal, along with soda, metallic tin is plentifully afforded. It is at present unknown whether this very desirable ore exists in workable quantity.

3. *Yttro-tantalite.*

A single small crystal supposed to be yttro-tantalite was detected along with the cassiterite. Its form is that of a right rhombic prism of about 122°, having its acute terminal angles replaced by two planes, inclining to one another across the obtuse lateral edge of the prism at an angle of very near 125°. Specific gravity = 6·001.

4. *Note upon the Paracolumbite.*

This ambiguous mineral, whose locality at Taunton, Mass., was lost sight of for many years, has been re-discovered; and still continues to be met with in collections under the above name. The analysis of Pisani proved that it had no chemical relation to columbite, but gave a result not altogether satisfactory for ilmenite, (menaccanite) to which he referred it. In view of its decidedly lower specific gravity than ilmenite, its fusibility before the blowpipe, and its large content of silicate of alumina, it remains undecided whether it properly belongs where Pisani has placed it; and I would therefore suggest that until farther information is obtained, the name paracolumbite be changed to para-ilmenite.

5. *Hemihedral forms of Staurolite.*

Among the large and perfect crystals of this mineral, found loose at Morganton, Ga., hemihedral forms are not unfrequent, both as single and compound crystals. The hemihedism relates to the alternate obtuse terminal angles, which are replaced by broad single planes.

* Possibly chiastolite may have been similarly produced, though the origin must have been attended with a more radical metamorphism.

6. *Fergusonite from Mitchell County, North Carolina, and identical with Rutherfordite.*

I have detected along with the samarskite of this locality a few very small crystals of fergusonite closely resembling those originally described by Haidinger as coming from Greenland, and nearly identical with those found in the sands from the gold washings of Rutherford, N. C., named by me as rutherfordite, and which I now consider as belonging to the species fergusonite.

7. *Green Pagodite in Georgia.*

A very handsome green variety of this mineral is found on Beaver-dam creek, nine miles west of Washington. It first attracted the notice of Mr. Ufford Jennings, of Charleston, S. C., as a material likely to be useful in ornamental stone-work. Its color, especially when polished, is between apple and emerald green. It has considerable translucency. Structure coarsely schistose, with a splintery fracture. Very tough. It is more or less interlaminated with coarse scales of muscovite; and is often freckled and blotched with a copper-red rutile; the latter impurity sometimes imparting after polishing, a resemblance to blood-stone. Hardness = 3. Gr. = 2·86. Before the blow-pipe in thin fragments, turns white and suffers slight fusion. Colors borax, apple-green. Uniformity of composition imperfect, owing to presence of muscovite and rutile. The trials gave

Si 48· to 52·, Al 22·6 to 34·, Fe 2·10, Na 5·12, K 4·43, H 3·5,
(Cr and Ti undetermined).

It probably forms a stratum of considerable dimensions in a mica-slate formation.

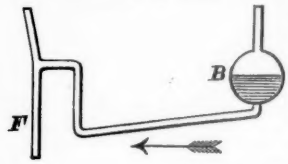
New Haven, May 8, 1880.

ART. VIII.—*On an improvement in the Sprengel Pump;* by Professor O. N. ROOD, of Columbia College.

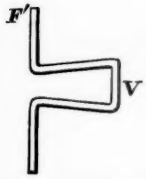
IN this notice I propose to indicate very briefly the nature of an improvement that I have lately made in the form of the Sprengel pump, which enables the experimenter easily to obtain a vacuum as high as $\frac{1}{90,000,000}$ or $\frac{1}{100,000,000}$, reserving the details of manipulation, etc., for more extended notice hereafter.

(1.) The improvement consists, first, in an arrangement by means of which the mercury, instead of being at once introduced into the pump, passes beforehand through an exhausted bulb B, thus freeing itself in great measure from air and moisture. It afterwards passes through a nearly horizontal tube, finally reaching the fall-tube F, as shown in the diagram.

(2.) The second part consists of what amounts to an almost theoretically perfect fluid valve, which prevents the air that has passed out of the fall-tube from returning into it; this is accomplished by merely bending the fall-tube as indicated at V. As for the rest, the pump is contrived so as to be free from stop-cocks and grease.



By inclining the pump somewhat, the bulb can be exhausted once for all, as matters can easily be arranged so that when the atmosphere is allowed to enter the pump, the exhaustion of the bulb remains intact.



The action of this pump is very rapid, two hours or less sufficing to reduce the vacuum from $\frac{1}{20,000}$ to $\frac{1}{100,000,000}$, the total capacity of the pump being 100 cubic centimeters.

The exhaustion in these experiments was always accomplished by mechanical, not by chemical means; chemical substances being introduced solely for the purpose of drying the air. In the total absence of all such substances I have obtained a vacuum as high as $\frac{1}{30,000,000}$. The means of measuring these vacua and other details will be given as soon as a set of experiments that are being made on the caliber of the fall-tube is finished.

New York, June 10th, 1880.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Carbonyl Bromide.*—Emmerling has met with serious difficulties in the attempt to prepare carbonyl bromide by the method proposed some years ago by Lengyn and himself for the preparation of carbonyl chloride, i. e., by the oxidation of chloroform by means of a mixture of potassium dichromate and sulphuric acid. The more energetic action of the oxidizing agent upon bromoform, especially when the proportions were used, which were found best for chloroform, caused so copious an evolution of carbon dioxide that the condensation of the carbonyl bromide by a freezing mixture was rendered well nigh impossible. By using a larger proportion of the dichromate—20 to 25 parts to 50 parts sulphuric acid and 5 to 10 bromoform—a somewhat less violent reaction takes place. Moreover in place of removing

the free bromine produced in the reaction by means of antimony, it was allowed to condense in the receiver with the bromide, and a crude product colored by bromine, was obtained, which weighed only 25 grams, after repeating the operation fifteen to twenty times. Subsequently by distilling this through a tube containing antimony, a colorless heavy liquid was collected, having the same penetrating suffocating odor that carbonyl chloride has, and whose vapor caused a remarkable swelling up of the vulcanized rubber connections. On fractioning, the thermometer rose from 12° to 30°; proving that the product was not pure. On analysis, it was found to contain carbonyl chloride.—*Ber. Berl. Chem. Ges.*, xiii, 873, May, 1880. G. F. B.

2. *On the Hydrate of Barium dioxide.*—SCHÖNE has made further analyses of the hydrate of barium dioxide, since his formula $BaO_2(H_2O)_8$, originally given for this substance, has been doubted by Berthelot, who assigns to it the composition $BaO_2(H_2O)_{10}$. The first set of analyses, in which he was assisted by Grigorieff, was made upon the product obtained by the spontaneous decomposition in water, of the compound $BaO_2 . H_2O_2$, at temperatures between 14° and 20° C. About 3¼ grams of the colorless crystals, prepared by mixing ice-cold solutions of ammonia and of hydrogen peroxide containing barium chloride, were placed in a flask with pure water, the progress of the decomposition being observed by collecting the evolved gas in a graduated tube. During the first seven days fifteen to thirty c.c. of gas was evolved in twenty-four hours. The crystal mass became at first yellow, and then colorless, and after four more days, during which only 4 c.c. of gas was evolved daily, there remained a colorless coarsely crystalline powder of the pure hydrate, weighing about five grams. A portion was dried rapidly by pressure between folds of paper. A second portion was rapidly dried by washing with alcohol and ether. Both samples on analysis gave the formula $BaO_2 . (H_2O)_8$. The second set of analyses was made on crystals obtained by pouring a dilute solution of hydrogen dioxide into barium hydrate solution in excess, all the operations being conducted between 0° and 5° C. The thin crystal plates were dried and analyzed. Allowing for a small quantity of carbonate formed, they gave the formula $BaO_2 . (H_2O)_8$ like the others. Hence this may be regarded as correct, corresponding as it does to the strontium and calcium compounds, which are $SrO_2 . (H_2O)_8$ and $CaO_2 . (H_2O)_8$.—*Ber. Berl. Chem. Ges.*, xiii, 803, Apr., 1880. G. F. B.

3. *On Furfuran and Sylvan in Pine wood tar.*—ATTERBERG has further examined the earlier fractions of the distillation of pine wood tar, in which he discovered the terpenes, australene and sylvestrene. The most volatile portion consisted of a liquid of characteristic odor, boiling at 30° and having a sp. gr. of 0·779. After distillation over sodium, it gave 72·71 C., 9·32 H, and 17·97 O, and had a vapor density of 69·5. It was evidently a mixture, but its behavior toward hydrochloric acid showed it to

contain a body C_4H_4O, discovered by Limpricht in 1870 and called tetraphenol, a name subsequently changed by Baeyer to furfuran. The addition of this acid converts it at once into a solid and almost insoluble powder. Associated with this was a hydrocarbon, probably a valerylene. The next higher fraction boiled between 59° and 65°. Distilled from sodium, the larger part of it boiled at 63° to 63·5°, gave on analysis C 73·50, H 8·78, and had a vapor density 81·4 to 81·7. The formula C_5H_6O requires 73·17 C and 7·32 H and a vapor density of 82. This is therefore a homologue of furfuran, and the author calls it sylvan, from its origin. Most reagents only polymerize it giving resinous and tarry products. Permanganate oxidizes its methyl group to acetic acid.—*Ber. Berl. Chem. Ges.*, xiii, 879, May, 1880. G. F. B.

4. *On Crystallized anhydrous Oxalic acid.*—The common oxalic acid, as is well known, is a crystallized hydrate $C_2H_2O_4 . (H_2O)_2$, which loses its crystal water on heating. Villiers has observed that this acid may be obtained in beautiful crystals containing no water by dissolving it in small quantities in warm concentrated sulphuric acid, about one part of oxalic acid to twelve of sulphuric. After some days, and even after months sometimes, octahedrons are deposited, having the composition $C_2H_2O_4$. They are bulky and very clear, and are right octahedrons with a rhombic base, generally modified by the face *p* of the fundamental prism. On exposure to the air, the crystals rapidly absorb water and lose their transparency, taking up two molecules of water, and effloresing in a curious manner. A furrow is formed at first along each of the edges of the octahedron, and the crystal splits into eight tetrahedrons, which rapidly fall to powder. In this octahedric form oxalic acid has so strong an attraction for water that on dissolving it in ordinary sulphuric acid, crystals of the hydrate are deposited. It sublimes, giving long prisms quite different in appearance from the crystals obtained by solution. Whether the acid is dimorphous the author has not been able to determine, owing to the minuteness of the crystals.—*Bull. Soc. Ch.*, II, xxxiii, 415, May, 1880. G. F. B.

5. *On the Continuous Preparation of Ethyl Acetate.*—Pabst has devised a continuous process for the preparation of acetic ether, analogous to that by which ethyl ether is made. A mixture of 50 c.c. of sulphuric acid and 50 c.c. of alcohol is introduced cold into a retort, and then by means of a funnel tube closed with a cock, equal molecules of alcohol and of glacial acetic acid—one liter of alcohol of 96 p. c., and one liter of acetic acid of 98 p. c.—are allowed to run into it slowly as soon as the temperature has reached 140°. At first a little ethyl ether distills over, but then a liquid begins to come over regularly which contains 85 p. c. of acetic ether. The reaction begins at 130° to 135°, and at 145° a little sulphurous oxide is formed. The sulphethylic acid formed is decomposed by the acetic acid and reformed again by the alcohol simultaneously added. The distillate is washed with a saturated solution of calcium chloride, dried over

the melted salt, and fractionated. In one operation 1350 grams of pure acetic ether was obtained, being 90 per cent of the theoretical yield. Methyl acetate is readily made in the same way, but amyl acetate requires too high a temperature.—*Bull. Soc. Ch.* II, xxxiii, 350, April, 1880. G. F. B.

6. *On the Alkaloids of Belladonna, Datura, Hyoscyamus and Duboisia.*—LADENBURG has continued his researches on the mydriatic—or pupil-dilating—alkaloids. He finds that *Atropa belladonna* contains at least two alkaloids, which, on account of their specific gravities, he distinguishes as heavy and light atropine. The former is the alkaloid known commonly by this name, $C_{17}H_{23}NO_3$. It is characterized by a lusterless gold salt fusing at 135°–137°. The latter fuses at 170°, forms a scarcely crystalline light powder, and gives a gold salt fusing at 159°. It must be considered as identical with hyoscyamine. *Datura stramonium* contains also two alkaloids, which also may be distinguished as heavy and light, the latter predominating. The difficultly soluble heavy daturine fuses at 113·5°–114°, and is a mixture of atropine and hyoscyamine, which may be separated by re-crystallizing the gold salts. Indeed, repeated re-crystallization of daturine from dilute alcohol, yields pure atropine. Light daturine is identical with hyoscyamine. *Hyoscyamus* contains two alkaloids, distinguished as crystalline and amorphous. The former gives a gold salt in brilliant plates fusing at 159°, and not fusing in boiling water like the atropine salt. Hyoscyamine itself fuses at 108·5°, atropine at 113·5°–114·5°. The former separates from its solutions as a gelatinous mass, and crystallizes only in fine needles. Amorphous hyoscyamine contains a new alkaloid, which forms a beautiful gold salt, fusing higher than those of atropine or hyoscyamine. The author is now investigating it. Duboisia yields only one alkaloid, duboisine, which the author has already identified with hyoscyamine.—*Ber. Berl. Chem. Ges.*, xiii, 909, May, 1880. G. F. B.

7. *On the Synthesis of Chinoline.*—KOENIGS has given a new and more convenient synthesis of chinoline. Baeyer's first synthesis was obtained with hydrocarbostyril, and the author's with allyl-aniline. He now finds that acrolein-aniline affords chinoline easily on dry distillation. The well-dried reddish-yellow mass was distilled in portions of 25 grams, and the distillate was purified by treatment with sulphuric acid and bichromate. It contains beside chinoline, a less volatile base. After repeated oxidation the chinoline was distilled from the alkaline liquid by a current of steam, and separated from the water by solution in ether. The yield is larger when one part aniline, 1½–2 parts sulphuric acid and one part of glycerin are heated to 180°–190°. Acrolein-aniline is formed and at once oxidized to chinoline. Skraup prefers a mixture of nitrobenzene and aniline, which affords 25 per cent of chinoline.—*Ber. Berl. Chem. Ges.*, xiii, 910, May, 1880.

G. F. B.

8. *On two Compounds formed by Urea with Gold Chloride.*—HEINTZ has shown that when gold chloride and urea are dissolved together, yellow crystals are deposited which are a mixture of two compounds of the gold chloride and urea, which are easily separated by recrystallization. One of these crystallizes in orange-red needle-like prisms, permanent in the air, and having the composition $AuCl_4H(CH_4N_2O).H_2O$. The other has the composition $AuCl_4H(CH_4N_2O)_2$. It crystallizes in fine yellow needles, is permanent in the air, and fuses at about 100°. Very soluble in water and also in alcohol and ether.—*Liebig's Annalen*, ccii, 264, April, 1880. G. F. B.

9. *Relation between the Velocity of Light and the Density of Bodies.*—Herr H. A. LORENTZ refers to the fact that Maxwell's theory of light has been examined chiefly in relation to the questions of velocity and of reflection and refraction, and proposes to himself to examine the relation between the index of refraction n and the density d of a body, under the supposition that Maxwell's theory is true. He starts with the hypothesis that an ether exists between the molecules of a body, and that in the immediate neighborhood of the molecule the state of this ether does not differ from that which it possesses in a vacuum. He also supposes that in each molecule of an isotropic body an electromotive force awakens an electrical moment proportional to itself and directed in like manner; that Coulomb's law holds for very small distances. Under these suppositions the calculations conduct to a relation between the specific inductive capacity K of a non-conductor and its density. Connecting this result with the equation $K=n^2$ found by Maxwell, the author finds that with a change of density the equation

$$\text{eq. (1)} \quad \frac{n^2-1}{(n^2+2)d} = \text{constant} = k$$

must hold. Under the supposition that all the molecules are not equal, one can obtain formulas for the index of refraction of a mixture. It follows that $\frac{n^2-1}{(n^2+2)d}$ also in this case must be equal to a constant, and also that between this value and the analogous constants $\frac{n_1^2-1}{(n_1^2+2)d_1}$, $\frac{n_2^2-1}{(n_2^2+2)d_2}$ etc., which result from the conditions of the mixture, the relation

$$\frac{n^2-1}{(n^2+2)d} = a_1\frac{n_1^2-1}{(n_1^2+2)d_1} + a_2\frac{n_2^2-1}{(n_2^2+2)d_2} + \text{etc.}$$

must hold. In this latter equation a_1, a_2, etc. are the units of mass of the portions in the unit of weight. The constant k in eq. (1) is found to be independent of the wave length of light; but calculations and comparisons are given which show that indices of refraction of glycerine, alcohol, chloride of zinc and sulphide of carbon change less than the theory indicates as the wave length of light diminishes. The author concludes that the departures of the observed from the calculated values, both in the case of solid

and fluid bodies must be ascribed to the same cause, and are in conformity with the fact that in flint glass the increase of the index of refraction is greater, the smaller the wave length employed, and that in crown glass the index of refraction diminishes with heating when great wave lengths are employed, and increases when small wave lengths are used. The author discusses the departures from his theory and intimates that they are due to certain electrical conditions among the molecules and atoms of compounds.—*Annalen der Physik und Chemie*, No. 4, 1880, p. 641. J. T.

10. *Aurora Borealis.*—In a recent paper read before the Royal Society, Mr. Warren de la Rue and Mr. Hugo W. Müller stated their conviction that at the height of 37·67 miles above the sea level, the atmosphere would have a pressure of 0·379 millim., and the display of the aurora would be of maximum brilliancy and would be visible at a distance of 585 miles. The greatest exhaustion they have been able to produce 0·000055 millim., corresponds to a height of 81·47 miles and 11,000 cells failed to produce a discharge in hydrogen at this pressure. At the height of 124·15 miles the pressure would be only 0·00000001 millim., and they do not believe that an electric discharge would occur "with any potential conceivable at such a height." The discharge in air at a pressure of 62^{mm} has a carmine tint, and corresponds to an altitude of 12·4 miles and would be visible at a distance of 356 miles. At pressure of $1·5^{mm}$ corresponding to a distance of 30·86 miles, the discharge becomes salmon colored and has lost the carmine tint. At a pressure of $0·8^{mm}$ corresponding to 33·96 miles, the discharge becomes of a paler salmon color, and merges into a pale milky white. The authors think it conceivable that the aurora "may occur at times at an altitude of a few thousand feet."—*Nature*, May 13, 1880, p. 33. J. T.

II. Geology and Mineralogy.

1. *Report on the Geology of the High Plateaus of Utah*, with Atlas; by C. E. Dutton, Captain of Ordnance, U. S. A., U. S. Geogr. and Geol. Survey of the Rocky Mountain Region, J. W. Powell in charge: Department of the Interior. 307 pp., 4to, with eleven heliotype plates, and a folio Atlas. Washington, 1880.—The region which is the subject of this report is one of unexcelled grandeur in the extent of its mountain plateaus, in its simple system of geological structure and displacements, and in the magnitude and diversity of the effects of erosion, and Captain Dutton, in his account of it, shows that he is capable of appreciating and discussing the geological problems which it presents.

The High Plateaus, as the Report states, occupy a large part of the southern half of Utah, commencing, on the north, at a point in the Wahsatch range about 15 miles east of Mount Nebo, and having a length of about 175 miles, with a breadth of 25 to 80 miles. The region is divided by two profound, nearly north and

south valleys; a western, along the Sevier River, which here flows north to the westward bend that takes it to Sevier Lake, "a wretched salina of the Great Basin;" and an eastern, called Grass Valley, along two tributaries of the Sevier, a northern and southern, which combine to make the "East Fork of this river." On the west of the Sevier Valley, three plateaus are distinguished, namely, commencing to the north: the Pavant, "a curious admixture of plateau and sierra;" the Tushar, "its northern half a wild, bristling cordillera, its southern, conspicuously tabular;" and the Markágunt, "a true plateau," about 11,000 feet in height. Between the Sevier and Grass Valleys there are two plateaus, the Sevier, 80 miles long, cut through near its middle by the east-and-west gorge of the East Fork; and south of this the Paunságunt plateau, "bounded on three sides by lofty battlements of marvelous sculpture and glowing color." East of Grass Valley, and its line to the south (along which commences the Paria River), three plateaus are distinguished: the Wahsatch, extending somewhat farther north than the Pavant (to the parallel of 40°), where it joins, in an *en echelon* way, the Wahsatch range proper; the Fish-Lake plateau east of Fish Lake, but 15 miles long, yet 11,400 feet high; the Awapa plateau, which almost blends with the preceding but is of less altitude, and is 30 miles long by 20 in breadth, its top a treeless, rolling prairie, sloping feebly to the eastward; and the Aquarius, 11,600 feet high in its eastern part, 35 miles in length by 10 to 18 in breadth, the grandest of all the High Plateaus, its "three sides, the south, west and east, walled by dark battlements of volcanic rock," and descending to "the dismal desert in the heart of the Plateau country," while its broad summit is clad with forests of spruce, and has its grassy parks and scores of snow-fed lakes.

The wonderful contrast between the desert country below to the south and southeast, "dismal and suggestive of the terrible," and the forest-covered summit of the Aquarius plateau, has much meteorological interest as regards the whole mountain region, and we cite a paragraph from page 285 of the report.

"The ascent leads us among rugged hills, almost mountainous in size, strewn with black bowlders, along precipitous ledges, and by the sides of cañons. Long detours must be made to escape the chasms and to avoid the taluses of fallen blocks; deep ravines must be crossed, projecting crags doubled, and lofty battlements scaled before the summit is reached. When the broad platform is gained the story of 'Jack and the beanstalk,' the finding of a strange and beautiful country somewhere up in the region of the clouds, no longer seems incongruous. Yesterday we were toiling over a burning soil, where nothing grows save the ashy-colored sage, the prickly pear, and a few cedars that writhe and contort their stunted limbs under a scorching sun. To-day we are among forests of rare beauty and luxuriance; the air is moist and cool, the grasses are green and rank, and hosts of flowers deck the turf like the hues of a Persian carpet. The forest opens in wide parks and winding avenues, which the fancy can easily people with fays

and woodland nymphs. On either side the sylvan walls look impenetrable, and for the most part so thickly is the ground strewn with fallen trees, that any attempt to enter is as serious a matter as forcing an *abattis*. The tall spruces (*Abies subalpina*) stand so close together, that even if the dead-wood were not there a passage would be almost impossible. Their slender trunks, as straight as lances, reach upward a hundred feet, ending in barbed points, and the contours of the foliage are as symmetrical and uniform as if every tree had been clipped for a lordly garden. They are too prim and monotonous for a high type of beauty; but not so the Engelmann spruces and great mountain firs (*A. Engelmanni*, *A. grandis*), which are delightfully varied, graceful in form, and rich in foliage. Rarely are these species found in such luxuriance and so variable in habit. In places where they are much exposed to the keen blasts of this altitude they do not grow into tall, majestic spires, but cower into the form of large bushes, with their branchlets thatched tightly together like a great hayrick."

This meteorological contrast, as the author remarks, is explained by the fact that the summit receives not far from 30 inches of rain a year, because so high among the clouds, while the low country around has but 4 to 8 inches.

The southern boundary of these High Plateaus is near the southern boundary of Utah, the parallel of 37°. Beyond, lies the Plateau country, described by Powell, the region of the Shiwits, Uinkaret, Kanab, Kaibab and Paria plateaus, on the north side of the "Grand Cañon" of the Colorado,—which here extends nearly east and west between the parallels of 36° and 36° 30′,—and of "Marble Cañon," "Kanab Cañon," "Hurricane Cliffs," "Echo Cliffs," and other remarkable features.*

The Henry Mountains, described by G. K. Gilbert, stand 30 miles to the east of the Aquarius plateau.

In the geological account of these plateaus the author treats of the geological formations, the positions and disturbances of the strata, and the bearing of the facts on questions connected with mountain-making, the distribution and character of the igneous rocks, the nature and origin of volcanic action, and the results, methods and period of erosion.

The distribution of the formations is exhibited on a large colored chart. They include the *Carboniferous*, making the summit and western side of the Pavant or northwestern plateau; the *Triassic*, in Western Utah, at the eastern base of the Awapa and Aquarius plateaus, and with it the *Jurassic*, and the latter also outcropping in narrow strips in the Sevier River Valley; the *Cretaceous* (with which the Laramie or Lignitic group is united by Captain Dutton), bordering the plateaus and rising, in several of them, nearly to the summit; the *Eocene Tertiary*, constituting part of the slopes on the north, south and east of the plateaus,

* See Powell's Report on the Uinta Mountains; also this Journal, III, xii, 420, and Dana's Manual of Geology, edition of 1880, page 792.

and making the summit formation of the Wahsatch Plateau on the north, of small portions of the Fish-Lake and Tushar plateaus, and of a large part of the Markágunt plateau in the southwest. Going from the southern plateaus southward to the Colorado, a wide area of Eocene Tertiary is first passed; then bands, in succession, of Cretaceous, Jurassic, Upper Trias, Lower Trias, (Shinarump Group), and Carboniferous.

The youngest group in the series clearly made out (the Quaternary excluded) is thus the Eocene; and it would be the summit formation generally were it not for the erosion that has taken place, and still more for the covering of igneous rocks. These Eocene beds are part of an extended lacustrine formation—as first recognized by Marsh. They are described as 5,000 feet thick around the flanks of the Uintas and southern Wahsatch, and as thinning, outward from these mountains, to nearly or quite 2,000 feet.

The volcanic rocks are spread over the summits of the Aquarius, Awapa and Fish-lake Plateaus on the east, the great central Sevier Plateau, and the Tushar and Markágunt Plateaus on the west; and they have a thickness in some parts of 4,000 or more feet. The rocks are chiefly trachytes, with some andesyte, propylyte and doleryte; and the trachytes are described as intermediate in age between the andesyte and propylyte, which are the oldest, and the dolerytes, but as in alternating beds in some places with the last. In the Awapa and Aquarius Plateaus, the trachyte shows a thickness, in some of the profound gorges, of 3,000 feet. The volcanic eruptions are stated to have begun in the middle Eocene, and a few of the foci are still distinguishable. The basaltic eruptions in some places look, "so far as appearance is concerned," as if they "might have been erupted less than a century ago." Besides the eruptive beds, volcanic conglomerates are widely distributed, they covering an area of 2,000 square miles, and being in some parts 2,500 feet thick. In some places they have been so changed as to lose their fragmental character, and become in appearance closely like true eruptive rocks (a fact which has been observed also in the Andes and in Mexico). But they fail, says Captain Dutton, of the fluidal character and glass inclusions of the latter. For the author's discussions with regard to the volcanic rocks and volcanic action and its causes, the reader is referred to the Report.

The disturbances in the plateau region have resulted in a general uplifting, and also in monoclinal flexures, and in fractures and faults; and the faults are mostly in the line of monoclinal uplifts, as brought out by Powell in his description of the Colorado region on the South. The flexures and faults, as is well illustrated in the Atlas, have approximately a north-and-south course, and are, in part, a continuation of those of the Colorado region on the South. The "Hurricane fault" has its southern limit at some undetermined point in Arizona, south of the Colorado, and, at its crossing of the Grand Cañon, it is the line of a displacement of 1800 feet. It is the western bound-

ary of the Markágunt uplift (the southwestern), making at one place a displacement of 5,000 feet, and at the southwest base of the Markágunt elevation, bringing up the Carboniferous to a level with the Tertiary, a displacement of 12,000 to 13,000 feet. It reaches north to the west side of the Tushar plateau and by the east side of the Pavant. Other faults have less extent, but there is great similarity among them in character and direction. The amount of throw is, in general, from a few hundred feet to 3,000 feet. The time when these displacements took place is not indicated by the displaced beds, for no beds occur later than Eocene. Captain Dutton refers the principal displacement to the middle Pliocene, and suggests, on the ground of facts connected with the erosion of the region, that some may have been formed even as late as subsequent to the Glacial period. These displacements are wholly distinct from those which occurred at the mountain-making epoch after the Laramie period, upturning the Cretaceous and inferior beds, being a result of subsequent movements. After that epoch a large part of the Rocky Mountains was raised from near the ocean's level; and the production of the monoclinal flexures, long lines of faults, great volcanic eruptions, and profound denudation must have been dependent more or less on this grand movement or the causes producing it.

Captain Dutton points out the contrast between the simple mononclinal flexures and nearly horizontal bedding of the Plateau mountain region and the high dips and numerous folds of the Appalachians. The contrast is not so striking when the comparison is made with the Cumberland Table Land and its continuation southwestward into Tennessee and northward into Southern New York and the Catskills, which are parts of the results of the Appalachian revolution; and may it not be that the High Plateaus are in a similar way the denuded outskirts of the Wahsatch, which afterward became somewhat crumpled and displaced, while the uplift of the Rocky Mountain region was in progress.

The subject of erosion is treated ably and with full appreciation of the grandeur and geological interest of the results in this Plateau region; and several heliotypes represent some of the wonderful scenes in the mountains. The author estimates that on an average, at least 6,000 feet of rock in depth have been removed from the Plateau Province since the erosion began, that is, during the Miocene and subsequent time—from an area of 10,000 square miles. The erosion was least in the High Plateaus, the average being less than 1,000 feet, chiefly because of the protection they received from the covering of volcanic rocks. He says (pp. 21, 22):

"The great erosion of the Plateau Province was most probably accomplished mainly in Miocene time, but continued with diminishing rapidity throughout the Pliocene. But it is necessary to say that the terms Miocene and Pliocene have here no definition. They cannot be correlated except in a very general manner with events occurring outside the province. We have only a vast stretch of time, with an initial epoch near the close of the local

Eocene. The greater part of the denudation is assigned to the Miocene, because the conditions appear to have been more favorable to a rapid rate of destruction in that age than subsequently. The climate appears to have been humid, while the elevation was at the same time gradually increasing, both conditions being favorable to a rapid disintegration and removal of the rocks. The Pliocene witnessed the gradual development of an arid climate similar to that now prevailing there. To this age belong the cañons and the great cliffs, which could not have been produced in an ordinary or humid climate, nor at low altitudes. That this aridity is by no means a condition of recent establishment is indicated by many evidences. They consist of remnants of a former topography, preserved in a few localities from the general wreck of the land, and which show the same general facies of cliffs and cañons as those of more recent formation. And as the more recent sculpture owes its peculiarities in great part to the aridity, so, we conclude, must these more ancient remnants. The Kaiparowits Plateau presents an excellent example. Its surface is in many places rendered utterly impassable by a plexus of sharp narrow cañons, of which the heads have been cut off by the recession of the gigantic cliff which forms the eastern wall of the plateau. They have long been dug, and have remained with but little change for an immense period of time.

"And now the relation of the High Plateaus to the Plateau Province at large becomes evident. They are the remnants of great masses of Tertiary and Cretaceous strata left by the immense denudation of the Plateau Province to the south and east. From the central part of the province the Tertiary beds have been wholly removed and nearly all of the Upper Cretaceous. A few remnants of the Lower Cretaceous stretch far out into the desert, and one long narrow causeway, the Kaiparowits Plateau, extends from the southeastern angle of the district of the High Plateaus far into the Central Province and almost joins the great Cretaceous mesas of Northeastern Arizona, being severed from them only by the Glen Cañon of the Colorado. The Jurassic has also been enormously eroded. This formation, which is of great importance and bulk in the northern and northwestern portion of the province, and especially around the High Plateaus, appears to have thinned out toward the south and southeast. In large portions of New Mexico it is wholly wanting and was probably never deposited there. In the northwestern portion of that Territory only a few thin beds of that age are found. But in the northern part of the province a conspicuous and wonderful sandstone formation of most persistent character is found, overlaid and underlaid by shales holding a distinctly Jurassic fauna. This formation once extended over the Grand Cañon area probably as far south as the river itself, and possibly farther, but has all been swept away as far north as the southern end of the district of High Plateaus. From the region east of the High Plateaus also very large areas of it have been removed. The Upper

Trias has also been greatly denuded, and the Lower Trias nearly as much so. The erosion of the Carboniferous has been small, being confined chiefly to the cutting of cañons—most notably the Grand and Marble Cañons, which are sunk wholly in that series; and in several places have been cut through the entire Palæozoic series system."

In the discussions with regard to the nature of volcanic action and the origin of mountain disturbances, Captain Dutton rejects the idea of the earth's interior liquidity, and holds that the theory of the earth's contraction, as a cause of movement, is inadequate to account for the facts. At the same time he acknowledges that, in his view, the source of the heat of volcanic action, and that of the force producing the greater changes of level in the earth's surface, are yet without satisfactory explanation. In connection with his remarks on the erosion in the Plateau region, he queries whether the removal of 6,000 to 10,000 feet of rock material over so large an area would not "have disturbed the earth's equilibrium of figure, and the earth, behaving as a quasi-plastic body, have re-asserted its equilibrium of figure, by making good a great part of the loss by drawing upon its whole mass beneath?" He further says that, to account for the uplifts as well, we must almost necessarily refer to the operations of "that mysterious plutonic force which seems to have been always at work and the operations of which constitute the darkest and most momentous problem of dynamical geology;" and also "recognize the coöperation of that tendency, which indubitably exists within the earth, to maintain the statical equilibrium of its levels." But to appreciate rightly the relations of the uplifts to the erosion, and their relative influence on this equilibrium, we have to remember that during the very period of erosion, when 6,000 feet in average depth was being removed (that is, after Eocene time), the mountain region was undergoing an elevation of full twice 6,000 feet.

But the reader should refer to the volume for the author's full discussions on these and the other topics, here briefly reported. The Report is made in all parts very readable by the author's graphic descriptions of the region and of the events in its geological history. J. D. D.

2. *Pennsylvania Geological Survey. The Geology of Mercer County;* by I. C. White. Report No. QQQ. 234 pp. 8vo, with a colored geological map of the county and 119 vertical sections.–This Report is occupied mostly with details respecting the strata and their coal beds, which pertain to the "Productive Coal measures," the conglomerate measures underneath, and the sub-conglomerate, which last are exposed to view only along the principal streams. A large part of the county is covered by Drift, and interesting observations are presented with regard to it. The distribution of large bowlders over the top surface of the Drift, and also in the body of it, leads the author to the conclusion that the transportation was not done by icebergs but by glacier ice. The fact that these bowlders are limited in their southward distribution in Western Pennsyl-

vania by the Ohio River, that they occur abundantly north of it, "covering the surface like flocks of sheep," and not south of it, where there is nothing in the topography to give such a limit to transport by icebergs, is stated to be evidence on this point. The author observes that the rivers of the county, like those of the adjoining Beaver and Lawrence Counties, discussed in his former report (No. QQ), flow over a great thickness of stratified silt, sand and gravel, even 700 feet in some cases, showing that the original rocky bottom is thus deeply buried.

3. *Annual Report of the Wisconsin Geological Survey for the year* 1879; by T. C. CHAMBERLIN, Chief Geologist. 72 pp. 8vo. Madison, Wisconsin, 1880.—Besides details respecting the distribution of collections of fossils, this Report contains descriptions of new Paleozoic fossils by R. P. Whitfield, and descriptions of three species of Fungi by W. F. Bundy. Of the fossils the following are from the Potsdam sandstone: *Holopea Sweeti*, *Conocephalites? quadratus*, *C.? explanatus*, *Ptychaspis striata*, *Dicellocephalus Lodensis*, and *Aglaspis Eatoni*. Mr. Whitfield describes also new species from the Trenton, Hudson River group, and Niagara, and one, a Discina, from beds of the Hamilton period.

4. *Report on the Florida Reefs;* by LOUIS AGASSIZ. Accompanied by illustrations of Florida Corals from drawings by A. SONREL, BURKHARDT, A. AGASSIZ and RŒTTER. Memoirs of the Museum of Comparative Zoology at Harvard College, vol. vii, No. 1. 62 pp. 4to. Plates I to XXIII. Cambridge, 1880.—This publication, by the Museum of Comparative Zoology, of Professor Louis Agassiz's Report on the Florida Coral Reefs, only extracts from which had appeared in the Coast Survey Report for 1851, is making accessible one of the most interesting of his memoirs, and giving it augmented value through the addition of plates of Florida Corals. These plates, which have great beauty and perfection, were drawn and lithographed for the original report, but were never published. To the volume Mr. Alexander Agassiz has added the sketch of Florida from Professor Agassiz's "Methods of Study," based upon his investigations of the reefs (all which were carried on under the auspices of the Coast Survey), and, for the convenience of the reader, a sketch map of Southern Florida and the Keys, compiled from Coast Survey Maps.

5. *Early Man in Britain, and his place in the Tertiary Period;* by W. BOYD DAWKINS, M.A., F.R.S., etc. 538 pp. 8vo, with many wood-cuts. London, 1880. (Macmillan & Co.).—This treatise, on Early Man in Britain, is by one of the ablest and most judicious geologists of Great Britain, who has done much "cave hunting," and speaks largely from personal observation. It follows a work on Cave Hunting by the same author, published in 1874. While devoted especially to facts in Britain, it gives a general review of those of Europe; and, besides treating of human remains, relics and early history, it embraces a comprehensive sketch of the Tertiary Mammalia, and of the geographical and climatal conditions and changes during the Tertiary and Quater-

nary. The illustrations—over 160 in number—are excellent, and include maps, copies of many sketches or drawings of the Stone age, and representations of human remains and implements, and other objects throwing light on ancient human history. With regard to man in the Tertiary, we cite a few sentences from the concluding chapter:

"Nor is it likely that he [Man] lived in Europe in the Pliocene age, after the land connecting Britain with Greenland had been submerged and the Atlantic was united to the North Sea and the Arctic Ocean, because the living species of Mammalia are so few. When the living species became abundant, he appears just in the Pleistocene stage in the evolution of Mammalian life in which he might be expected to appear. The River-drift man first comes before us, endowed with all human attributes, and without any signs of a closer alliance with the lower animals than is presented by the savages of to-day," "as a hunter, armed with rude stone implements, living not merely in Britain, but throughout Western and Southern Europe, Northern Africa, Asia Minor, and India. Next follows the Cave man, possessed of better implements, and endowed with the faculty of representing animal forms with extraordinary fidelity, living in Europe north of the Alps and Pyrenees, as far as Derbyshire, and probably belonging to the same race as the Eskimos."

6. *Recent action of Mauna Loa and Kilauea;* by T. Coan. (From a letter to the editors, dated Hilo, Hawaii, May 3d to 6th, 1880).—Hilo is in a haze of sulphur smoke, and we see the sun as through smoked glass. We have a grand volcanic eruption.

On the first inst. a little before daylight, a herdsman, who lives about two miles out of town, reported that he had seen a light on Mauna Loa. At 8 P. M. of the same day, my wife called my attention to an unusual light in the direction of the mountain. At first it was partly obscured by clouds, so that we hesitated to pronounce it volcanic. In a few minutes, however, the revelation was clear. The clouds dispersed and the spectacle of a burning mountain opened to our sight. The action was intense. The appearance was as if a vast column of melted rock, a mile in diameter, was being poured out of the mountain with amazing force and vehement heat. Brilliant corruscations shot out in all directions, lighting up the clouds to the apparent height of 30° and spreading out for many miles along the summit of the eastern side of the mountain. The outbreak was in full view from the west side of our house, which was brilliantly lighted up by the fires, while the front part was in a deep shade, rendering the contrast striking.

This eruption occurring in the night, we were unable to determine at once its exact locality. Some thought it was in the deep summit crater, Mokuaweoweo; and others that it was at a point a few miles north of it. Since that night the mountain has been so veiled in clouds and smoke that we have not been able to see the fire. Yesterday flocks of Pele's hair, and light particles of

volcanic dust and sand were dropped upon our houses and in our streets, over our walks and our gardens, having been borne upon the winds for this great distance.

May 6. Our mail leaves to-day, and I deeply regret that we have not seen the great fire since the night of the first and second inst. A dense cloud has rested upon the mountain by night and day, so impervious that no light shines through it.

We have, however, learned by people coming from Puna, and from Kau, *via* Kilauea, that the roaring furnace is still in fierce blasts, and that its locality is probably in the terminal crater, Mokuaweoweo. Some affirm that there are three points of active eruption upon the mountain, and that lava streams are flowing, but these reports are not fully reliable.

Optical delusion and excited imagination often see unreal visions. During the terrific eruption and the rending earthquakes of 1868, men and women of entire veracity saw, as they thought, rivers of fire come down from the mountain and plunge into the sea, within three miles of them, and all this in open day, with nothing to obstruct their view, and yet, on going to the place where this lava flowed, as they asserted in all honesty, there was no mark or smell of fire.

Since my former letter, dated June 20, 1879, *Kilauea* has resumed great activity. Rarely in its recorded history have the fires been more intense or the filling up more rapid. The number of visitors is fast increasing, and they all bring glowing reports of the intense activity of the fires.

Lateral streams of liquid rock are bursting through the scoriaceous sides of Halemaumau—the lake and cone in the southwest part of the crater—and flowing down the declivities into the central depression, adding stratum to stratum, while the great lake boils, and dashes its waves against its walls, and sends its burning spray high into the air. The debris around the high walls of the lake is so hot and brittle that most parties who visit the crater do not venture near the burning cauldron, but mount some quiet eminence about one-quarter of a mile from its margin, where they can witness its ragings, and listen to its splashings and mutterings with safety.

7. *Glaciation of the Shetland Isles.*—A paper on this subject, well illustrated by a geological map showing the direction of the glacial striæ, by B. N. Peach and J. Horne, is published in the Quarterly Journal of the Geological Society for 1879.

8. *Relief Geological Map of New Hampshire.*—A relief geological map of the State of New Hampshire, after Professor C. H. Hitchcock's geological map, on the scale of two and a half miles to the inch and measuring four feet by six, is being made by Mr. Joseph Schedler, a map engraver of New York City.

9. *Brief Notices of some recently described Minerals.—Fredricite*:—A mineral related to tetrahedrite, but characterized by its containing lead and tin. It occurs only massive; the color is iron-black; hardness $=3{\cdot}5$; specific gravity $=4{\cdot}65$. An analysis yielded:

S	As	Cu	Pb	Sn	Ag	Fe	Sb		
27·18	17·11	42·23	3·34	1·41	2·87	6·02	*tr.*	=	100·16

This corresponds to the general formula $4RS, As_2S_3$, or that of an arsenical tetrahedrite. It is described by Hj. Sjögren as occurring with galenite and geocronite at the Falu mine in Sweden. —*Geol. För. Förhandl. Stockholm*, v, 82, March, 1880.

Orizite:—Occurs in minute crystals and crystalline grains, having the luster and color of rice kernels. Hardness =6; specific gravity =2·245. The composition is the same as that of heulandite with which it is considered by the describer, G. Grattarola, as dimorphous. Locality: the tourmaline granite of San Piero in Campo.—*Atti Soc. Toscana*, ii, 7.

Pseudonatrolite:—Occurs in minute colorless crystals, probably orthorhombic. Hardness =6; luster glassy to pearly. An analysis afforded:

SiO_2	Al_2O_3	CaO	MgO	Na_2O,K_2O		
62·64	14·76	8·54	*tr.*	1·00	=	101·76

It is regarded as a new zeolite. Described by Grattarola (l. c.) from the same locality as *orizite*.

Mallardite; Luckite:—Two minerals from the Lucky Boy silver mine, Butterfield Cañon, Utah; described by A. Carnot (C. R., lxxxviii, 1268, 1879). *Mallardite* occurs crystallized in a gray clay-like vein stone with quartz and barite. When fresh it is colorless but changes rapidly in the air, effloresces and becomes opaque. The composition is expressed by the formula $MnSO_4+7$ aq, or the same as the artificial salt.

Luckite is found in indistinct striated prisms of a bluish color, occurring in a black bituminous rock. It probably belongs to the monoclinic system. The composition, as given by the analysis, corresponds to the formula (Mn, Fe) SO_4+7 aq. It is consequently near to mallardite but contains 21·7 p. c. FeO.

Guejarite:—Occurs with siderite in the copper veins in the distrite of Guejar, Andalousia. It is found in orthorhombic crystals of a steel gray color. Hardness =3·5; specific gravity =5·03. The chemical composition is given by the formula $Cu_2S+2Sb_2S_3$, which places it near chalcostibite. Described by Cumenge and Friedel.—*Bull. Soc. Min. France*, Nov., 1879.

Beccarite:—A variety of zircon, differing from that mineral in its optically biaxial character, and in composition. An analysis gave:

SiO_2	ZrO_2	Al_2O_3	CaO	Ign		
30·30	62·16	2·52	3·62	0·32	=	98·92

Brought by Dr. Beccari from Point de Galles, Ceylon, and described by G. Grattarola.—*Atti Soc. Tosc.*, vi, 1879.

Mixite:—An emerald- to bluish-green mineral as an incrustation on bismuth ochre, and also in granular, and irregular massive particles, sometimes spherical in form and in part crypto-crystalline. An analysis yielded:

As_2O_5,P_2O_5	Bi_2O_3	CuO	FeO	CaO	H_2O		
30·45	13·07	43·21	1·52	0·83	11·07	=	100·21

The empirical formula obtained is $Cu_{20}Bi_2As_{10}H_{44}O_{70}$. Described by Schrauf as occurring with torbernite and bismutite at Joachimsthal.—*Zeitsch. Kryst.*, iv, 277, 1880.

10. *Analysis of the Meteoric Iron from Cleberne Co., Alabama;* by J. B. MACKINTOSH, E.M. (Communicated by W. E. Hidden.) —The following is an analysis of the meteoric iron from Chulafinnee, Cleberne Co., Ala., described by W. E. Hidden, in the May number (p. 370) of this Journal; the analysis is by J. B. Mackintosh:

Fe 91·608, Ni 7·368, Co 0·500, P 0·170=99·646

11. Thirtieth and Thirty-first Annual Reports of the New York State Museum of Natural History. Albany, 1879.—The first of these reports, "transmitted to the Legislature April 13, 1877," contains the Report of the Botanist, C. H. Peck, occupying 56 pages; a paper on the lithology of the Adirondacks, by A. R. Leeds, 32 pages; another on the structure of *Astræospongia meniscus*, by Drs. J. W. Hall and R. Fritz-Gærtner, 6 pages; and entomological contributions, No. IV, by J. A. Lintner, 130 pages. The second contains: a Report of the Botanist, C. H. Peck; notes on some sections of Trilobites from the Trenton Limestone, note upon the eggs of the Trilobite, and descriptions of new species of fossils from the Chazy and Trenton Limestone, by C. D. Wolcott; and notes on Phlogopite, by R. Fritz-Gærtner.

III. BOTANY AND ZOOLOGY.

1. *Action of Light on Vegetation.*—It is well understood that, for a plant to complete its development and mature its seeds, a certain sum of heat is required, varying according to the species. It appears -- as indeed might antecedently be expected, — that we should rather say a certain amount of solar radiation; for light, to a certain extent, may replace temperature. This is shown in the effects of almost uninterrupted summer sunshine upon vegetation in high latitudes. According to Schübeler of Christiania and others, barley ripens in 89 days from the sowing in Finland, while it requires 100 days in the south of Sweden, though the latter enjoys a considerably higher temperature. A grain of wheat grown at near the sea-level in Norway, or in lower latitudes, when propagated at high elevations or in a high latitude will mature earlier, even although at a lower temperature; and it is said that, within limits compatible with its cultivation, the grain increases in size and weight. Is this the case with Minnesota and Manitoba spring wheat?

It is inferred, and in various ways seems to be made out, that this is owing to the greater amount of light of the prolonged summer days and of the higher altitude,—a natural explanation, since it is normally or mainly under light that nutritive matter is formed. But we are not told whether the crop of Finland barley raised in 89 days, was as large as that produced in 100 days in southern Sweden under a greater sum of heat but a smaller amount of light. It is said, indeed, that the grain of wheat under such conditions is of greater size and weight, but not that the produce to the acre, or the number of grains to the ear, is increased. From the analogy of Indian corn in this country, the contrary

might be expected. This crop in Lower Canada may ripen in fewer days than in Alabama, but only a precocious variety of dwarf stature and scanty product can there be raised at all in the short interval between vernal and autumnal frosts. But maize may be regarded as a tropical plant, inured to northern latitudes only by the development of precocious and dwarf varieties, and, requiring a longer season and a greater sum of heat than barley, it cannot be grown at all in latitudes high enough to enjoy this short but almost continuous sunshine.

That prolonged illumination may thus make up for a certain diminution of temperature is also inferred from the fact that the plants of high northern Europe produce larger and greener leaves than southern individuals of the same species, and the increased brightness of color in blossoms is adverted to in the same sense. Schübeler is said to have shown that biennials and perennials under these conditions lay up a greater store of nutritive matter. Flahault has carried on a series of comparative experiments in this regard, simultaneously conducted at Upsal and Paris. The mean temperature of the summer months differs only slightly, and the rain-fall is nearly the same in the two places. But the mean length of the day, between the 15th of May and the 30th of July is 17 hours 49 minutes at Upsal; at Paris, 15 hours and 38 minutes. These experiments are detailed at length in his paper in Ann. Sci. Nat. (Bot.) 6th Ser., ix, p. 159, etc., March, 1880,—to be concluded in the April number. The results, so far, favor the above mentioned conclusion.

Schübeler also makes out that grain, after several generations of cultivation in the highest latitudes or the highest elevation compatible with its cultivation, will when transferred back to its original locality ripen earlier than grain which has not been moved. But it loses this precocity in a few generations, and the seeds gradually diminish to the former size and weight. Plants raised from seeds ripened in a high northern locality are hardier than those grown in the south, and are better able to resist excessive winter cold.

Analogous conclusions are reached from the celebrated recent experiments of Dr. Siemens in England, in which the work of the sun is done by the electric light. He confirms in a striking way, —what had been otherwise shown in France,—that artificial light, even lamp-light, when of sufficient intensity, will produce all the effects of sunlight; that the electric light is particularly efficacious in producing chlorophyll and promoting growth; that an electric light equal to that of 1400 candles at a distance of two meters from growing plants has about the effect of average day-light in England; and that, while under its influence plants can sustain high stove heat without suffering. As plants run their course advantageously in the continuous day-light of an arctic summer, with mere diurnal diminution at night-fall, so Dr. Siemens has shown that electrically illuminated plants require no diurnal rest, but can be forced on, at least for a considerable time, and

their development be thereby greatly expedited. Plants can be grown, therefore, by electric light,—by its aid, energy can be stored up in food and fuel,—which is an interesting rounding of the cycle of transformation; and if the contemplated electro-horticulture fails to be established, it will be because it cannot be made to pay.

An interesting portion of Flahault's paper, above mentioned (pp. 171–177), is occupied with the investigation of the cases in which chlorophyll is formed in darkness. There are two kinds of cases. 1. The cotyledons of Pines, though colorless up to the moment of germination, then turn to bright green even when light has no access to them. Here the green is certainly due to the formation of chlorophyll, and to its production without the intervention of light. This chlorophyll is here formed at the expense of nutritive matter of the albumen of the seed, taken into the cotyledons, i. e., is formed from reserve-material. Flahault finds that the young leaves of Onion and of Crocus, developing from the bulb, fed by reserve-material, equally may form some chlorophyll in darkness. Various Ferns, growing almost in darkness, have a bright green color, from well-developed chlorophyll, which must also originate from stored nutritive material; for Borodine has shown that Fern-spores will not germinate and develope in darkness, although they contain a certain amount of nutritive matter. 2. The other case is the familiar one of a bright green embryo in the seed from the time of its formation, as in Radish, Violet, Maple, and many others. But here the embryo is not formed in darkness; the coverings or surrounding parts are to a certain and considerable extent translucent, and the chlorophyll is formed during the growth of the well-developed embryo. The peculiarity is, that this chlorophyll remains for a very long while unaltered in darkness, ready to perform its functions the moment that germination brings these green cotyledons to the light of day.

Finally, there are the new researches of Pringsheim of Berlin, on the nature and functions of chlorophyll, which have attracted much attention. He infers that the physiological use of the green matter is to protect the protoplasm from combustion, or to moderate respiration; the protoplasm itself being the true agent of assimilation. Apparently he does not raise the pertinent enquiry why it is only that protoplasm which is in direct connection or union with chlorophyll which assimilates carbon dioxide at all. We await the future paper, promised by Pringsheim, in which his results and inferences may be further and more clearly developed.

A. G.

2. *Criticism of the accounts of the Brains of the Lower Vertebrates given in Packard's Zoology*;* by BURT G. WILDER.—It is to be hoped that Dr. Packard may have the cordial coöperation of zoologists in the effort to free the second edition of his text-

*Zoology for Students and General Readers; by A. S. Packard, Jr., M.D. The American Science Series, No. VI, 1879.

book from the defects which have in some degree impaired the usefulness of the first.

Notwithstanding the assistance of Professors Cope and Gill upon the parts relating to the Batrachians and Fishes, perhaps no portions of the work stand in greater need of revision than the accounts of the brains of these groups.

There are inconsistent, incomplete, unintelligible and incorrect statements, and for convenience I mention the more important imperfections under these heads.

A. Inconsistent statements.—(1) Page 407, the "nervous cord of Amphioxus does not enlarge in the head to form the brain;" page 640, "there is only a very slight enlargement of the anterior end of the spinal cord."

(2) Page 426, "the brain of the Ganoids, including Dipnoans, is as in the Elasmobranchs;" page 428, "from the nature of their brain and heart the Dipnoans are quite different from all other fishes."

B. Seriously incomplete statements.—(1) The description of the brain of "Pisces" (p. 411) applies equally well to the Batrachians and lamprey eels. (2) Page 407, the ventricle on the dorsal side of the cephalic end of the spinal cord of Amphioxus is not mentioned. (3) There is no allusion to the size and complexity of the cerebellum of most sharks, or to the apparent consolidation of the so-called "hemispheres" into a single median mass. (4) Strictly speaking, and especially in view of the published opinion of the reviser as to the "taxonomic value of the brain and heart," none of the brains of "fishes" are sufficiently described.

C. Unintelligible Statements. — (1) The brains of Marsipobranchs (p. 409), of Elasmobranchs (p. 417), and of Batrachians (p. 469), are said to be "much as in the fishes" or, "like that of fishes in general." But the reader is left in doubt as to the meaning of the word "fishes," since in the section on Teleosts it is repeatedly used as a synonym of the bony fishes alone: on page 405 it is equivalent to "Pisces;" while in the Preface it evidently denotes all below Batrachians.

D. Incorrect statements. — (1) In whatever way the word "fishes" be interpreted, the intimations of any close resemblance between their brains and those of Marsipobranchs, Elasmobranchs, and Batrachians are without foundation in fact. Especially is this the case with the group last named, since neither the Ganoids proper nor the Teleosts have been shown to possess true hemispheres, lateral lobes containing each a ventricle.

(2) Page 409, the cerebellum of the Marsipobranchs is "apparently not differentiated from the medulla." This may be true of the hag-fishes, but in lampreys the cerebellum is perfectly distinct, and larger relatively than in Menobranchus.

(3) Page 417, "the brain of Elasmobranchs is like that of fishes in general, the olfactory lobes being large and long in the skates." All investigators of fish-brains agree that the brains of the sharks, skates, and Chimæra are difficult to homologize with those of other "fishes." The olfactory lobes are likewise large and long in some sharks.

(4) From the description and figure (pp. 440, 441) of what purports to be a typical Teleostean brain, the following inferences are inevitable: bony fishes have neither thalami nor olfactory lobes; the "hemispheres" are the most anterior pair of lobes, and are similar to the true hemispheres of Batrachians. As to the optic nerves, the professed anatomist might see in the appearances presented by the side view of the brain in fig. 400, signs of their origin from the optic lobes; but the "student and general reader" would hardly venture upon this interpretation in the absence of previous explicit statement with respect to any vertebrate, and against the more obvious signification of the following sentence upon page 440, "In front arise the very large and conspicuous optic nerves."

In view of the unsatisfactory nature of our knowledge of the structure and homologies of the brains of the lower vertebrates. would it not be well for the author to state the difficulty of giving brief and at the same time accurate generalizations concerning them, and to confine himself to a somewhat full account of the brain of some Batrachain, employing as a basis the admirable paper of the late Jeffries Wyman upon "The Nervous System of *Rana pipiens*." Attention should be called to the fact that in frogs and toads the olfactory lobes, by a rare exception, are in contact upon the middle line. The brains of Menobranchus and other tailed Batrachians do not present this rather perplexing characteristic. Menobranchus abounds in the western lakes and rivers, and in the lakes of central New York, and has some other features which especially adapt it for dissection as a typical vertebrate.

IV. Miscellaneous Scientific Intelligence.

1. *Centennial of the American Academy of Arts and Sciences.*—The American Academy, (Boston and Cambridge), which received its charter from the Commonwealth of Massachusetts in May, 1770, celebrated its hundredth anniversary on the 26th of May last. Invitations had been duly sent to all the Associate Fellows resident in other States, and to its 70 Foreign Honorary Members. Societies with which it is in correspondence, both in this country and in the Old World, were apprised of this celebration. Several of the leading Scientific Societies of the United States were represented by a delegation, notably the American Philosophical Society at Philadelphia, which was incorporated a few months earlier, and which had celebrated the centennary of its charted existence in March, although the society was organized ten or twelve years earlier.

Several foreign academies sent formal responses and congratulatory addresses; a few were represented by delegates chosen by the several societies from among their American corresponding or honorary members, and one, the Cambridge Philosophical Society, sent a representative, Prof. Greenhill, a Fellow of Immanuel College, the college of John Harvard.

The officers of the Academy and the Committee of Arrangements, having charge of the celebration, received the invited guests and delegates at the Academy's rooms at noon, and escorted them to the "Old South" church, now a historical museum, where the public exercises were held. A historical address was there to have been pronounced by the distinguished President of the Academy, the Hon. Charles Francis Adams. But his strength gave way at the last moment, and he was unable even to be present upon the occasion. His address will, however, without doubt, form a part of the printed account of the centennial celebration. In his absence, and upon marvellously short notice, a most appropriate and excellent address was pronounced by the accomplished chairman of the committee of arrangements, the Hon. Robert C. Winthrop, a lineal descendant of the first president, Governor Bowdoin, and whose associations with the Academy were therefore little less intimate than those of Mr. Adams, whose father and grandfather had been presidents of the society before him.

A poem, written for the occasion, was delivered by Dr. Oliver Wendell Holmes, and short addresses followed from a surviving Ex-president (Professor Gray), Prof. Wm. B. Rogers, and from the Very Rev. Dr. Howson, the Dean of Chester, who was present as a guest.

The Fellows of the Academy then repaired to their hall, at the Athenæum, where a bountiful collation was spread. At its close short addresses were made by several delegates, by the President of Harvard University, and others.

At the adjourned annual meeting, on the 9th of June, Mr. Adams having declined further service, Professor Joseph Lovering was elected President, and Professor Oliver Wendell Holmes, Vice-President. Professors Cooke and Trowbridge were re-elected Secretaries.

2. *On the Recurrence of Solar Eclipses, with Tables of Eclipses*, from B. C. 700 to A. D. 2300.—This is the title of a paper by Prof. Simon Newcomb, Superintendent of the American Ephemeris and Nautical Almanac, to which the attention of teachers should be specially called.

It is a new method, and by far the most simple and most remarkable that has ever been published; presenting an entirely new theory of their recurrence, founded on properties of the Cycle called the Saros, which have hitherto not been observed or utilized. The moon's orbit, as well as that of the sun, is divided naturally by this cycle into 223 equal parts, and the points of division are called by the author "conjunction points." All solar eclipses are then naturally divided into classes and grouped together by the conjunction point at which they must occur. Each group extends over a period of more than a thousand years, the individual eclipses of a group, however, being separated, of course, by the interval of the saros—18 years and 10 or 11 days. The number of eclipses belonging to each group is therefore between sixty and seventy. The first of a group occurring at the

descending node takes place near the north pole of the earth, each succeeding one a little further south, and finally the last passes off near the south pole. The order is reversed for a group that occurs at the ascending node. Formulæ are deduced by which tables are so constructed that the time of the occurrence of any one of the group is found by first deducing approximately that of the central one, the number of the cycle of the required one, and thence the exact time of its occurrence. The number of eclipses of any year, and the time of their occurrence, is the work of but a few moments.

The student generally learns to compute eclipses altogether mechanically, without seeing any connection between his work and theory, and so loses very soon his interest in any of the usual methods. But experience with a small class proves it is not so with this. He realizes the connection between the tables and formulæ, seems to apprehend clearly every step he takes, is astonished to find he can so readily trace the shadow path over the surface of the earth, determine any phase at any point of it he chooses, and most of all, surprised to find he can do all this for an eclipse to occur a hundred years hence, a hundred years ago, or for *any one in the whole period of* 3,000 *years*, just as readily and accurately as for one that is to occur in the immediate future.

It is very desirable that an interest in the method may be taken by educators, such that the author may be induced to prepare an edition specially adapted to students. A. H. BUCHANAN.

Cumberland University, Lebanon, Tenn.

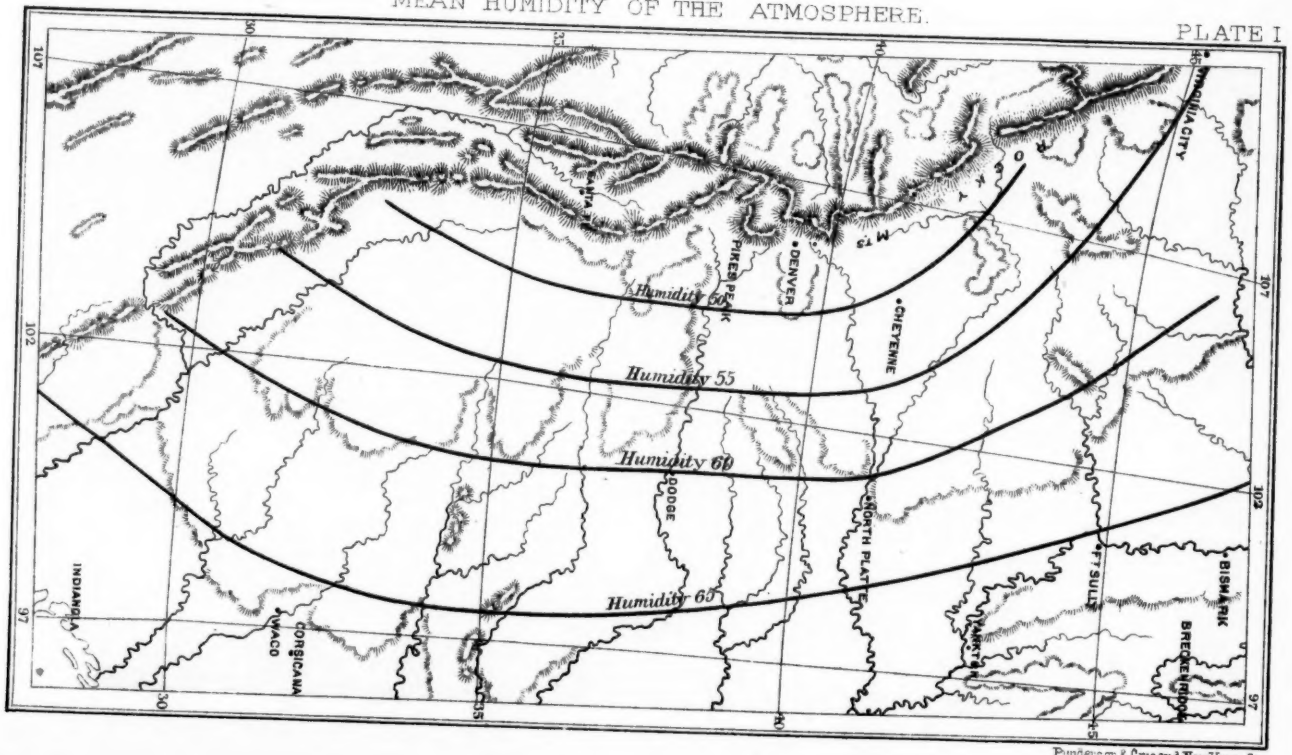
3. *Multiplication and Division Table, containing the products of numbers between* 1 *and* 100, *for the use of Accountants, Computers, and Teachers in the Primary Schools;* by LEONARD WALDO, S.D. (Harv.). New York, 1880. (John Wiley & Sons). Those who have much arithmetical computing to do, will find their work greatly facilitated by the use of these tables, and will appreciate their value. As regards clearness and neatness of typographical work they are all that could be desired; a smaller page might perhaps have been more convenient.

4. *Special Report of the New York State Survey on the Preservation of the Scenery of Niagara Falls, and Fourth Annual Report on the Triangulation of the State for the year* 1879; JAMES T. GARDNER, Director. 96 pp. 8vo. Albany, 1880.—This Report makes a strong appeal in behalf of a cause which is of universal interest, that is, the restoration and preservation of the natural attractions of Niagara Falls. It is to be hoped that the necessary action will be taken by the State to accomplish this important end. The volume contains a fine series of photographic views illustrating the points raised in the Report. The second part gives a statement of the results accomplished by the Topographical Survey in 1879.

The Winchester Observatory of Yale College: Circular of the Horological and Thermometrical Bureaus; published by the Observatory Board of Managers for the information of persons interested in these public services. Second Edition, 8 pp. 4to. New Haven, Conn., 1880.—This circular will be noticed in another number.

MEAN HUMIDITY OF THE ATMOSPHERE.

PLATE I



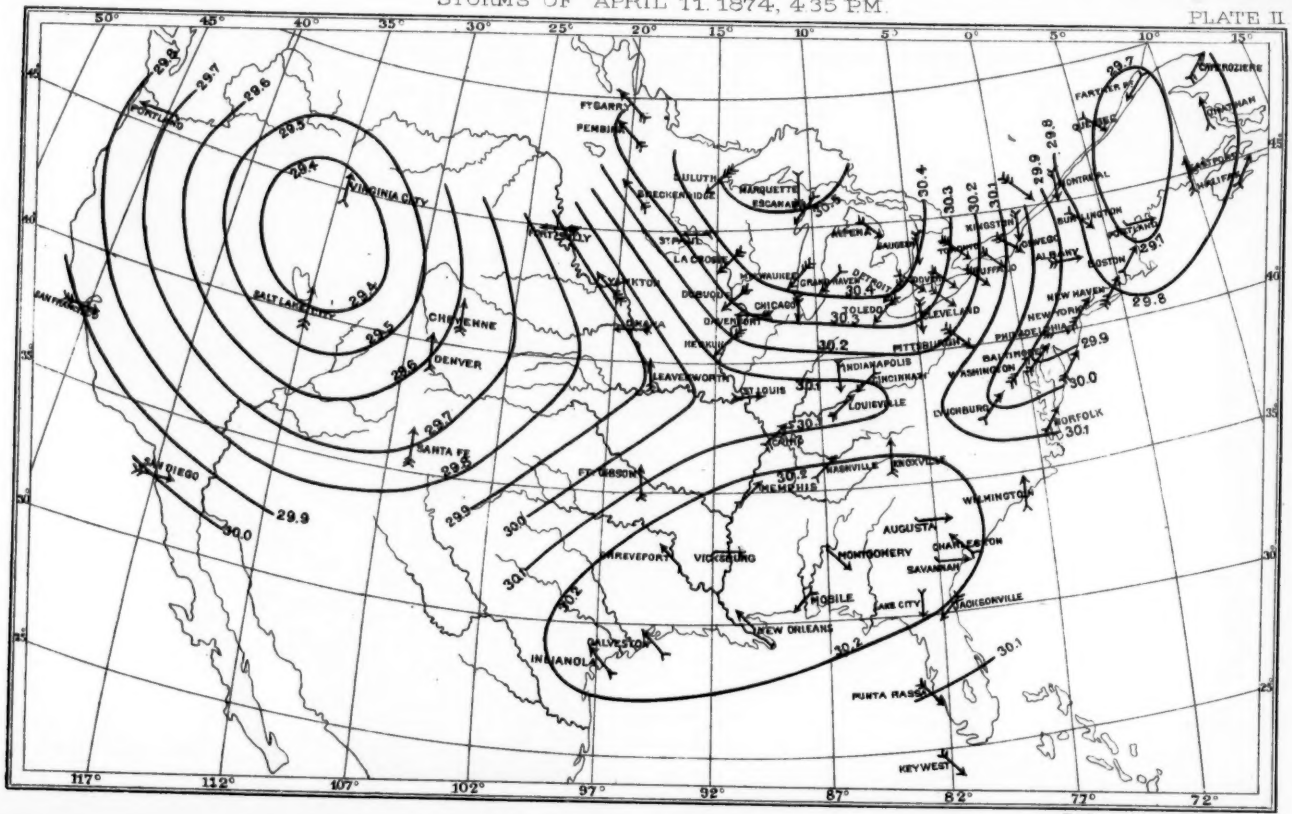
Punderson & Crisand, New Haven, Ct

STORMS OF APRIL 11. 1874, 4:35 P.M.

PLATE II

STORMS OF APRIL 11. 1874, 4.35 P.M.

PLATE II



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